MISSOURI BLUE RIBBON PANEL ON HYPERLOOP

Report prepared for The Honorable Elijah Haahr

Speaker of the Missouri House of Representatives

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Introduction

On March 12, 2019, Missouri House Speaker Elijah Haahr announced the formation of a special Blue Ribbon Panel on Hyperloop (BRPH). The BRPH, chaired by Lieutenant Governor Mike Kehoe, was tasked with presenting a report detailing specific steps that would enable Missouri to become "the global epicenter for the research, development, and commercialization" of tubed transport technology. Specifically, the Blue Ribbon Panel was asked to focus on two primary objectives:

- Determine how to establish Missouri as the global epicenter for research and development of this technology, which would significantly benefit our higher education, logistics, tech, and advanced manufacturing sectors.
- Study how various funding and financing strategies for major civil infrastructure projects around the world could apply to building the envisioned Missouri route, with a particular emphasis on public-private partnership structures that alleviate risk to taxpayers.

At the organizational meeting of the BRPH, held in Jefferson City, Missouri on March 25th, 2019, members agreed to form a series of subcommittees or working groups focused on the following key topic areas:

1) Economic Impact and Cost-Benefit Analysis
2) Regulatory and Legislative Frameworks
3) Funding and Financing Strategies
4) Higher Education Partnerships and the R&D Ecosystem

Members also reviewed the first North American feasibility study on the technology, produced by Kansas City engineering firm Black & Veatch and Olsson. The study was released in October of 2018.

While Missouri enjoys a significant “first-mover advantage” due to the Black & Veatch feasibility study as well as broad public and private-sector engagement across the state, this advantage will dissipate should we fail to capitalize on our momentum.

This document, the final report of the BRPH to Speaker Haahr, is therefore intended to extend Missouri’s momentum by providing state officials, regulators, technology promoters, and other interested parties with a plan that will meet the two primary objectives of Speaker Haahr’s goal of establishing Missouri as the global epicenter for tubed transport technology.

Executive Summary

The Speaker's Blue Ribbon Panel on Hyperloop (BRPH) finds substantial benefits to building a tubed transport (i.e., "hyperloop") system in Missouri:

- The new economic megaregion created by linking Kansas City, Columbia, and St. Louis via hyperloop would rank among the top 10 in the United States, significantly improving Missouri's global competitiveness for high quality jobs and talent;
- By leveraging the strengths of the University of Missouri system to convene a research and development consortium among major institutions, the state's flagship public university would establish itself as a leader in an emerging technical field that is attractive to students, professors, grant issuers, and corporate funders; and
- Missouri manufacturers and farmers would benefit by being linked to a new mode of light cargo delivery, which would ultimately allow their products to reach external markets more quickly and efficiently.

While construction of an inter-city commercial route (and ultimately a national network) remains the long-term objective, the BRPH believes that the logical and necessary next step in the process is the construction of a National Certification Track of up to 15 miles in length. The National Certification Track would serve as the natural center for research and development of the technology and should be supported by a robust ecosystem of academic and industry partners led by the University of Missouri system.

Construction of this hyperloop system in Missouri would result in these measurable economic, social, and educational benefits for the state:

- An estimated annual economic impact of $1.67 -- $3.68 billion;
- The creation of between 7,600 and 17,200 new jobs;
- Increased real estate values around portal locations;

- A significant strengthening of key industry clusters, including Automotive, Chemical Products, Business Services, Tech, Transportation and Logistics, and Aerospace;
- Increased tax revenues for state and local jurisdictions;
- A reduction of over 530,000 metric tons of CO_2 emissions.

Therefore, in light of these findings and based upon extensive independent research as detailed in the main report to follow, the BRPH recommends the following measures:

1. The state of Missouri should take steps to facilitate the construction of a National Certification Track in the state as the first phase of building The Missouri Hyperloop Project.

   As described in the main report to follow, construction of the National Certification Track is the first major phase of a multi-phased project that will ensure Missouri's connectivity to an envisioned national hyperloop network.

2. Should The Missouri Hyperloop Project move forward, it could be built through a public-private partnership that delivers the project in the safest, fastest and most responsible way possible, delivering the full array of project benefits while mitigating the risks to taxpayers.

   > Missouri cannot complete the National Certification Track, and certainly not the whole system alone. This will require a true Public-Private Partnership to realize all the benefits while protecting the interests of Missouri's taxpayers. However, it is clear that Missouri is the most attractive place to begin a national hyperloop system and therefore beginning in Missouri is the best interest of the nation. For this reason, we believe that the state should take the lead to establish a public-private partnership to explore further funding, finance and how to deliver the project while mitigating risk to taxpayers.

3. The University of Missouri system should take the lead in convening a consortium of universities around an International Tube Transport Center of Excellence.

The University of Missouri system has already established a clear lead in terms of hyperloop research and development via its participation in the Missouri Feasibility Study with Black & Veatch and Virgin Hyperloop One. It has also begun the process of reaching out to prospective university partners to form an International Tube Transport Center of Excellence, leveraging the resources and expertise of multiple institutions.

A National Certification Track in Missouri

Before a new transportation technology can be brought to market, it must undergo a rigorous testing and certification process. During the design and construction phase of the US Interstate Highway System, the Department of Transportation (DOT) operated a number of test highways where new materials and engineering techniques were assessed.[1] More recent examples include the Transportation Technology Center, a railway test track and laboratory operated by the American Association of Railroads in Pueblo, Colorado as well as 10 unique automated vehicle proving grounds authorized by the US DOT.

When an incremental improvement in an existing mode of transportation comes to market, such as a new aircraft model or automobile engine type, it benefits from the history of safety and reliability of the underlying technology. Such improvements also tend to fall clearly within the jurisdiction of one (or more) of the 11 administrations of the US DOT.

Because tubed transport is truly a new mode of transportation, rather than an incremental improvement upon an existing one, it does not fall neatly into the regulatory portfolio of any existing DOT administration. Arguments have been made that tubed transport systems:

- Utilize a maglev guided rail system that would likely fall under the authority of the Federal Railroad Administration (FRA)
- Utilize specialized vehicles traveling at high speeds within a low-pressure environment that simulates high-altitude travel, potentially giving the Federal Aviation Administration (FAA) jurisdiction
- Will likely follow the footprint of the Interstate Highway System and should therefore be regulated by the Federal Highway Administration (FHWA)
- Are contained within a pipeline, giving potential regulatory authority to the Pipeline and Hazardous Materials Safety Administration (PHMSA)

A counterargument is that, given the radical new nature of this technology, it should have its own, independent administration within the DOT with regulatory oversight. While each of

[1] Earl Swift, The Big Roads (need pg. #s)

these arguments have merit and deserve further consideration from regulators and lawmakers, our objective is to catalyze and accelerate the commercialization of the technology in Missouri within a relatively short time horizon of 3-5 years. In the Regulatory Framework section of this report, we describe potential scenarios under which Missouri could begin the work of building a tubed transport system though a "phased" approach that leverages the expertise of existing agencies and existing regulations.

Regardless of which agency(ies) are given regulatory authority over tubed transport, the fact remains that testing and certification of a full-scale, commercially-viable system using the current generation of technology are necessary and critical steps before rollout of a passenger or cargo-ready product.

Given the anticipated costs of the linear infrastructure required to build a tubed transport system[2], it makes sense to pool resources and focus on a single site for research, development, and certification of the technology.

The state or region that successfully builds the certification track will virtually guarantee themselves as a key "node" on a future network, coupled with the resulting social and economic benefits.

If Missouri is to meet the Speaker's objective of becoming the global epicenter for the research, development, and certification of tubed transport technology, it must focus on becoming the regulatory certification site for this new technology.

[2] Missouri Feasibility Study (need pg. #s)

Track Specifications

Based on our research, which includes discussions with tubed transport technology providers as well as a review of studies in Europe, the Middle East, and India, we conclude a track of approximately 12-15 miles would be sufficient for regulatory review and safety certification.

The certification track should be built in phases, beginning with a one to three-mile segment to permit initial testing of core technology components. A track of this size would represent a significant advance over current beta testing facilities in the Netherlands (0.02 miles) and Nevada (0.31 miles).

The essential components of any certification track would include:

- Vacuum tubes
- Pylons
- High speed switches
- Airlocks
- Magnetic levitation and propulsion system
- Guidance system
- Pods
- Portal

The alignment geometry of any certification track is also an important consideration. Aside from the prospective length of the full certification track (anticipated at approximately 12-15 miles), the system should be able to demonstrate the ability to turn and move along natural elevation changes.

According to a 2017 paper prepared by Delft University for the Dutch Ministry of Infrastructure and Environment, it would be possible to house multiple technology platforms within a single vacuum tube.[3] Under such a scenario, technology providers such as Virgin Hyperloop One (US), Hardt Hyperloop (EU), TransPod (CA) and others would be able to operate their own individual

[3] Hyperloop in the Netherlands, Anna van Buerenplein August 2017 pg. 6

systems within the certification track. However, recent conversations with technology providers suggest that this approach is not viable due to space constraints within the tube.

At least one technology provider, Virgin Hyperloop One, has indicated its intention to issue a national Request-for-Proposals (RFP) to construct a National Certification Track using its proprietary technology. Based on the work done by Black & Veatch and Olsson in the Missouri Feasibility Study as well as the work done by this Blue Ribbon Panel, Missouri should be prepared to submit a robust and competitive proposal.

SECTION 1: International Tube Transport Center of Excellence (ITTCE)

For Missouri to realize its objective of becoming the global epicenter for the research, development, and commercialization of hyperloop technology, there must be seamless collaboration among the public sector, private sector, and the higher education community. The University of Missouri is well positioned to convene a consortium of research institutions around an International Tube Transport Center of Excellence (ITTCE). The volume of passenger and freight travel across Missouri is extraordinary. The cities of St. Louis, Kansas City, and Springfield are major hubs for freight traffic. St. Louis, for example, sees an estimated $8 billion in river cargo traveling through its ports each year. It is also at the intersection of I-64, I-70, I-44, and I-55, making it critical to the movement of truck-based freight across the country. Kansas City and St. Louis are the second and third largest rail transportation centers in the nation, and Missouri is near the geographical population center of the US. This results in high amounts of ground and air passenger movement across the state. Kansas City sits at the intersections of I-35, I-29, I-49, and I-70, making it the 3rd largest trucking center in the United States. It also has one of the largest air cargo facilities in the Midwest, second to Chicago. The University of Missouri has the expertise, capacity, and strategic partnerships in place to accelerate the successful establishment of tube transport in the US and worldwide.

Center Objectives

The International Tube Transport Center of Excellence (ITTCE) Program is being formed to develop long-term partnerships among industry, academy, and government. The ITTCE program seeks to achieve these goals by:

- Contributing to the nation's research enterprise by developing **long-term partnerships** among industry, academy, and government;
- Leveraging federal funding with industry to **support graduate students** performing industrially relevant pre-competitive research;
- Expanding the innovation capacity of our **nation's competitive workforce** through partnerships between industries and universities;

- Encouraging the **nation's research enterprise to remain competitive** through active engagement with academic and industrial leaders throughout the world;
- Increasing the **resiliency** and **sustainability** of the transportation sector by expediting the launch of tube transport in the US, enabled by cutting-edge, collaborative research and robust test-bed validation; and
- Contributing to **national security and defense** by researching alternative mass transportation technologies that reduce dependence on conventional transportation networks such as highways and railroads.

Research Areas

Broadly speaking, the problem set to be addressed by ITTCE would include, but not be limited to, the following topics:

Magnetic levitation and propulsion technology

Geoengineering of the pressurized tubes and support systems

Advanced materials

Vehicle automation

Light cargo logistics

Multimodal connectivity (i.e., with airports, riverports, etc.)

Funding and financing strategies, including public private partnerships

Human safety

Aerospace engineering related to pod design and operation in low pressure environments

Interstate regulation of new modes of transportation

Civil engineering for linear infrastructure

Terminal design

Enhanced reality computer modeling

Renewable energy and environmental impact

Academic Partners

The University of Missouri has assembled an outstanding team of academic partners in the region that provide significant depth to the critical research areas to be addressed by ITTCE. Each university partner would bring something unique to the consortium. Participating universities will have preferred access to the proposed tube transport certification track as well as commercial labs for research and development purposes. Grant funding may be available via the Department of Transportation's Tier 1 University Transportation Center Program. Perhaps most importantly, the consortium would play a formative role in the design and commercialization of a national tube transport system.

University of Missouri

The University of Missouri's College of Engineering has a long history of researching innovative transportation technologies. In the 1990s, Professor Henry Liu pioneered the pipeline transportation technology for efficiently moving freight. The College is home to the ***Center for Excellence in Logistics and Distribution (CELDi)***, a long-standing industry consortium formed with the support of the National Science Foundation. The Center, comprised of faculty from Industrial and Manufacturing Systems Engineering and Transportation, has partnered with the trucking industry, railroad industry, and Amtrak to optimize freight movement. In a recent study, Center Director Jim Noble designed an underground freight pipeline system that utilizes capsules to transport cargo in pressurized tubes.

The University of Missouri System is home to the newly established Missouri Center for Transportation Innovation (MCTI) – in partnership with the Missouri Department of Transportation, the Federal Highway Administration, and many other agency and industrial stakeholders in the transportation sector. Led by Center Director Bill Buttlar of Mizzou, Deputy Director John Myers of Missouri S&T, along with transportation colleagues at UMKC and UMSL, MCTI will coordinate and propel transportation research in Missouri and beyond. MCTI's research and education priorities include innovation in transportation safety, sustainability, affordability, resiliency, and durability. Clearly, the hyperloop mode of transportation would have transformational impact on all of the MCTI priority areas, and is therefore of keen interest to the center, its researchers, and its partners.

The University of Missouri system is home to the following major transportation-related centers and labs:

- Missouri Center for Transportation Innovation (MCTI) (https://MCTI.Missouri.edu/)
- Center for Excellence in Logistics and Distribution, CELDi (https://celdi.org/)
- Center for Inspecting and Preserving Infrastructure through Robotic Exploration: INSPIRE (https://inspire-utc.mst.edu/)
- Center for Aerospace Manufacturing Technologies (https://camt.mst.edu/)
- Zou Sim (http://engineers.missouri.edu/csun/zousim/)

- Immersive Visualization Lab, iLAB (http://arch.missouri.edu/ilab/)
- Center for Innovative Materials and Structural Systems for Transportation Infrastructure (https://recast.mst.edu/)
- Center for Infrastructure Engineering Studies, CIES (https://cies.mst.edu/)
- The Center for Electromagnetic Compatibility (https://camt.mst.edu/industrialconsortium/)
- Industry consortia, including Dow, Boeing, Siemens (http://emc-center.org/CEMC.aspx)

University of Illinois at Urbana-Champaign

Like Missouri, the state of Illinois is a major ***multi-modal transportation hub*** in the US, connecting major interstate corridors (I-80, I-88, I-90, I-94, I-55, I-57, I-64, and I-72), waterways (the Great Lake system, Illinois, Ohio and Mississippi rivers, Illinois-Michigan canal), airports (O'Hare, Midway) and major rail lines. The University of Illinois at Urbana-Champaign (UIUC) has boasted a ***leading transportation program*** for over 100 years, and is a current/recent home for the following major transportation-related institutes, centers and labs:

- Discovery Partners Institute (https://dpi.uillinois.edu)
- The Illinois Center for Transportation (https://www.ict.illinois.edu)
- RailTec Center (https://railtec.illinois.edu/)
- NuRail Center (http://www.nurailcenter.org/), a Tier-1 University Transportation Center
- Center of Excellence for Airport Technology (https://cee.illinois.edu/research/research-centers)
- Center for Power Optimization of Electro-thermal Systems (https://poets-erc.org/)
- Materials Research Lab (https://mrl.illinois.edu)

Partnership with UIUC brings ***outstanding academic and industrial partners*** in the areas of Civil, Environmental, Electrical, Mechanical, Computer Science, Industrial, and Aerospace Engineering, along with Material Science and Physics. Furthermore, by partnering with Illinois through the Discovery Partners Institute, physically located in Chicago Illinois, we will have streamlined access to DPI's academic, agency, and industrial partners. These include the

University of Illinois at Chicago, Northwestern University, Southern Illinois University, the City of Chicago, and the Illinois Toll Highway Authority.

Purdue

Purdue is another engineering powerhouse proposed for the ITTCE consortium, boasting over 450 faculty, with dozens working in fields related to ITTCE. Purdue has maintained top-rated departments in Civil, Mechanical, Electrical, Computer Science, and Industrial Engineering, and also features a unique program in Aeronautics/Astronautics Engineering that produced a highly distinguished alumnus - **Neil Armstrong**. Purdue is also home to a number of centers related to ITTCE, including:

- The Purdue Energetics Research Center, PERC (https://engineering.purdue.edu/Energetics)
- Composites Manufacturing & Simulation Center, CMSC (https://www.purdue.edu/cmsc/)
- Center for Integrated Systems in Aerospace, ISA
- Center for Research on Earthquake Engineering and Disaster Data Management, CREEDD (https://datacenterhub.org)
- Center for Resilient Infrastructures, Systems, and Processes, CRISP, (https://engineering.purdue.edu/CRISP)
- Joint Transportation Research Program, JTRP (https://engineering.purdue.edu/JTRP)

University of Louisville

The University of Louisville (UL) Additive Manufacturing Institute of Science and Technology (AMIST) has a long history of innovative solutions to complex problems. Established in 1993, AMIST provides applied research, materials testing and professional training in additive manufacturing to clients from industry and government, producing prototypes and low volume end-use parts. The emphasis at AMIST is on laser and e-beam powder bed processes for metals, plastics and ceramics. Leading a broad range of additive manufacturing (AM) research

activities, UL faculty research is funded by industry and multiple federal agencies, including DoD (Navy, Air Force and Army), NASA and NSF.

UL is also a member of AmericaMakes and partners with leading AM users such as:

- Boeing
- General Electric (GE)
- Electronic Wind Instruments (EWI)
- Eastman Chemical
- Emerson
- Northrop-Grumman
- Burton
- Integra

In addition, the University of Louisville and AMIST are now part of NSF's National Nanotechnology Coordinating Infrastructure (www.NNCI.net). The UL node in this network, Kentucky Multi-scale Manufacturing and Nano Integration Node (MMNIN), is focused on integrating manufacturing technology over widely different length scales, that is, combining micro/nano fabrication processes with 3D additive manufacturing. Such integrated devices can provide new solutions to real-life problems in healthcare, energy, the environment, communications, and security.

Iowa State University

Iowa State engineering is led by over 300 faculty, conducting $100M of research annually, and has the 8th largest undergraduate student bodies in the US (>9,500 students). Some of the key research centers and institutes related to the proposed ITTCE at ISU are:

- Ames Lab of the US Dept. of Energy (https://www.ameslab.gov/)
- Institute for Transportation (https://intrans.iastate.edu/)
- Virtual Reality Applications Center (http://www.vrac.iastate.edu/)

- Center for Advanced Non-Ferrous Structural Alloys (www.CANFSA.org)
- Bridge Engineering Center (https://bec.iastate.edu/)
- Electric Power Research Center (http://powerweb.ece.iastate.edu/welcome-to-the-electric-power-research-center/)
- Center for Nondestructive Evaluation (http://www.cnde.iastate.edu/)
- Center for eDesign (http://centerforedesign.org/)

Washington University in St. Louis

Located in St. Louis, 'Wash U' boasts leading research and education programs in engineering, law, medicine, the Olin Business School and the Sam Fox School of Design and Visual Arts. The Electrical Engineering faculty include world-renowned experts in advanced sensor technologies (battery-free, wireless, resilient, and connected) and structural health monitoring. Faculty in the Sam Fox School of Design and Visual Arts are already actively engaged in hyperloop urban planning studies. Wash U's centers and labs include:

- Institute of Materials Science & Engineering (https://imse.wustl.edu/)
- Spartan Light Metal Products Makerspace (https://jubelmakerspace.wustl.edu/)
- Nano Research Facility & Jens Lab (https://nano.wustl.edu/)
- Center for High Performance Computing (https://research.wustl.edu/core-facilities/center-high-performance-computing/)
- Institute for Materials Science and Engineering (https://research.wustl.edu/core-facilities/institute-materials-science-engineering/)

University of Kansas

College of Engineering at the University of Kansas (KU) has several departments closely aligned with the ITTCE. These include: Civil, Environmental and Architecture Engineering, Electrical Engineering and Computer Science, Aerospace Engineering, Engineering Management and Project Management, Engineering Physics, and Mechanical Engineering.

Some of the key research centers and institutes related to the proposed ITTCE at KU are:

- Civil and Architectural Engineering Laboratories - http://ceae.ku.edu/facilities
- Research Clusters in Electrical Engineering and Computer Science - http://eecs.ku.edu/research-home
- Propulsion, UAS, Aerodynamics research - http://ae.engr.ku.edu/research-areas

Kansas State University

The Carl R. Ice College of Engineering at Kansas State University (K-State) has world-class programs in various engineering disciplines and is home to numerous research centers. In relation to ITTCE, significant strengths include research in logistics, advanced manufacturing, cybersecurity, mechatronics, sensors, transportation, power systems, and civil infrastructure systems.

Some of the key research centers and institutes related to the proposed ITTCE at K-State Engineering are:

- Civil and Transportation Infrastructure Engineering Laboratories - https://www.ce.ksu.edu/research/
- Core research areas in Computer Science (Cybersecurity, Cyber Physical Systems, Data Science, High assurance software) - http://www.cs.ksu.edu/research/
- Wireless communications, Power systems and smart grids - http://www.ece.k-state.edu/research/
- Advanced manufacturing, Operations research, Systems engineering research - https://www.imse.ksu.edu/research/

Other Academic Partners

In addition to these established Tier 1 partners, researchers from Arizona State, Indian Institute of Technology-Mumbai, Carnegie Mellon University, Penn State University, and University of

Pittsburgh have also expressed interest in partnering on this initiative. University of Missouri is engaging with interested faculty and research centers at these top-tier research institutions for their participation in the Center.

Center Structure and Governance

The ITTCE will be structured as an Industry-University Consortium. The University of Missouri will form and coordinate multi-university research teams to pursue a variety of pre-competitive research projects. (Pre-competitive projects are those that represent industry needs rather than proprietary solutions provided by individual members.) The shared research portfolio is cooperatively defined and selected by the participating university partners. Industrial members pool their funding investments to address pre-competitive shared needs, such as constructing and operating the test track and certification operations. Members will meet quarterly to apprise status, set direction, and coordinate projects. Governance decisions are made by member vote.

The ITTCE (in cooperation with member Tech Transfer organizations) will develop a robust agreement to foster collaboration, while ensuring equitable assignment and proportioning of individually- and co-developed intellectual property (IP). Because co-development of IP will involve collaborating with industrial and agency partners, the agreement will also cover co-developed IP across all stakeholder groups, creating an attractive, innovative research ecosystem. Industry members will receive royalty-free nonexclusive access to any IP created by jointly-funded ITTCE programs. Individual members may also separately contract with the ITTCE or individual universities to sponsor proprietary research that may result in IP licensed solely to the member company.

The University of Missouri will coordinate securing and administering research funding, and managing/prioritizing requests for researcher access to the International Certification Track in Missouri, and other administrative functions of the ITTCE.

Promising areas of federal funding include:

- University Transportation Centers program
- NSF Engineering Research Center program

- NSF Industry-University Cooperative Research Center (I/U CRC)

Potential industry partners include:

- Hyperloop Technology Companies (Virgin Hyperloop One, Hyperloop Transportation Technologies, Hardt Hyperloop)
- Potential Pod Builders (Boeing, Airbus, Bombardier, Embraer-Empresa Brasileira)
- Electric Propulsion Technology Suppliers ()
- Battery Technology Providers ()
- Vacuum Pump Manufacturers ()
- Logistics Companies (UPS, FedEx, DHL, Union Pacific)
- eCommerce Companies (Amazon, Walmart)
- Radio Pharmaceuticals (Cardinal Health, GE Healthcare, Lantheus, Novartis)
- Construction and Materials (Dow Chemical, Emory Sapp and Sons, Nucore Corp., Skyline Steel, Continental Cement Co., St. Genevieve Cement Plant, Capital Paving, Farmers Concrete Co., Herzog, DeLong's Inc.)
- Engineering Firms (Black & Veatch, Burns & McDonnell)

SECTION 2: Regulation and Legislation

Missouri's Public-Private Partnerships (P3) Statute

Missouri law allows public private partnerships for certain types of transportation projects.[4] The law requires that the Missouri Highways and Transportation Commission (Commission) approval of state-sponsored projects, but was recently changed to allow political subdivisions to advance projects without Commission approval. The law allows P3s for "any…airport, railroad, light rail, vehicle parking facility, mass transit facility, or other similar facility currently available or to be made available to a government entity for public use, including any structure, parking area, appurtenance and other property required to operate the structure or facility to be financed, developed, and/or operated under agreement between the commission and a private partner."[5] The law does not allow projects for "any highway, interstate or bridge construction, or any rest area, rest stop, or truck parking facility connected to an interstate or other highway under the authority of the commission." It states that any project not specifically listed, shall not be financed, developed, or operated by a private partner until such project is approved by a vote of the people.[6]

We likely would need the legislature to clarify that a Tube Transport System (TTS) is eligible for a P3. We also would need to be able to establish that a certification track is available for public use even if we could not make an initial showing that the project will improve or is needed as a necessary addition to the state transportation system (since it will be only a certification track).[7] The law also requires that the governmental entity retain control over rates charged, which may be a barrier since the TTS ultimately will cross state lines.

[4] Missouri Public Private Partnerships Transportation Act. Missouri Revised Statutes Title XIV. Roads and Waterways § 227.600-669.
[5] *Id.* at §227.600.
[6] *Id.*
[7] *Id.*

Lack of Federal Regulatory Regime

Currently, no regulatory framework exists for the certification and governance of tubed transport technology in the United States. To address this jurisdictional gap, Secretary of Transportation Elaine Chao announced on March 12th, 2019 the formation the Non-traditional and Emerging Transportation Technologies Council (NETT Council), an internal working group within the US Department of Transportation. The purpose of the NETT Council is to facilitate safe and responsible innovation in mobility technology by coordinating more effectively with industry representatives, state officials, and regulators of existing modalities.

The USDOT consists of 11 operating administrations, such as the Federal Aviation Administration, the Federal Rail Administration, and the Federal Transit Administration, that each have their own traditional jurisdiction over certain environmental and regulatory approvals.

Because Tubed transport technology does not fit neatly into any of the existing portfolios of these operating administrations, the NETT Council is seeking input on the best approach to certify and regulate the technology.

State Sponsor

In order to enter into any P3 contract for the Missouri Hyperloop Project, Missouri would need to certify a project sponsor. A project sponsor is any entity authorized by the state of Missouri to procure and implement the Missouri Hyperloop Project while ensuring that the public interest is protected. It will be important to designate a single Project Sponsor with the appropriate authority in order to avoid duplication and confusion as to which State entity is responsible for the Project.

Access to Highway Right-of-Way for Construction and Operation of Tubed Transportation System

We understand that the Missouri Highways and Transportation Commission acquires rights-of-way for its highways either by condemnation or by acquiring easements. Missouri law authorizes the State Highways and Transportation Commission to "purchase, lease, or condemn, lands in the name of the state for certain enumerated purposes when necessary for the proper and economical construction and maintenance of state highways." The enumerated purposes for which the Transportation Commission can acquire land include acquiring (1) "the right-of-way for the location, construction, reconstruction, widening, improvement or maintenance of any state highway or any part thereof," and (2) "lands for any other purpose necessary for the proper and economical construction of the state highway system for which the commission may have authority granted by law". Mo. Rev. Stat. 227.120. According to Missouri DOT, its right-of-way easements and deeds specify that property will be used for a highway purpose.

There appear to be different options for Missouri DOT to use state highway right-of-way to build a TTS track.

We also could argue that TTS is a highway purpose since it will transport goods or people. Since TTS was not envisioned when the legislation was enacted, the better approach may be for the Missouri legislature to amend section 227.120 to clarify that TTS is a highway purpose. That would remove any ambiguity that could lead to litigation. The best path would be to obtain clarification that construction of a TTS is eligible either as a highway purpose or a utility. Depending on how the easements are drafted, we may be able to argue that construction and operation of a TTS track is within the scope of the terms of the easement, and there is some support in Missouri caselaw for such an approach. Property owned by Missouri DOT in fee simple could be used for construction of a TTS track assuming Missouri DOT has confirmation that such a use was permissible under the statute.

Environmental Impact

Major federal actions, which include applications for financial assistance and funding from the federal government, will trigger requirements for an environmental review under the National Environmental Policy Act (NEPA). NEPA requires that federal agencies consider the environmental consequences of actions before those actions are taken, and identify, measure to avoid, minimize and/or mitigate the adverse effects of the proposed actions. General NEPA guidelines are established by the White House's Council of Environmental Quality. The specific process for conducting a NEPA review for the Missouri Hyperloop project will depend upon which federal agency is designated as the lead agency but will generally be required to develop either a Categorical Exclusion, EA, or EIS process. Given the geographic extent and public visibility of the planned Missouri Hyperloop project, it is most likely that the more extensive and time consuming EIS process will be triggered. Depending upon the source of federal funding and agency asserting primary jurisdiction over the Missouri Hyperloop development, it is likely that either the FRA or the FHWA will serve as the lead federal agency for the NEPA review. The FRA uses a tiered NEPA review process. Tier 1 reviews provide a programmatic overview of the entire project and would identify all potential resources that might be impacted along the route corridor. For rail projects, a "Service NEPA" also is typically completed by the FRA with the Tier 1 to address questions and effects relating to alternatives for route, stations, and other facilities; and alternatives for service including type, level of service, and operating technology. The Tier 1 review may be followed by a Tier 2 review that examines the site-specific project impacts. The Tier 2 review would also address any agency consultations, approvals, and permits that will be required for the project to move forward. Sometimes large, expansive projects are addressed in a single Tier 1 EIS process that involves several rounds of review. Once all tiers have been completed and approved, the project may move forward. FHWA's environmental review process is known as the Planning and Environmental Linkages (PEL) Program. PEL is designed to encourage transportation decision makers to incorporate environmental, community, and economic goals early in the planning process. As part of this process, the transportation planners, NEPA practitioners, FHWA staff, and the public to work together to identify and incorporate environmental and community values into the project

from design to completion. By facilitating the incorporation of information and results produced during the transportation planning stage into the subsequent NEPA review process, the PEL approach seeks to provide for a more unified decision-making process that reduces duplication of efforts. Following completion of the PEL, the next tier/stage would involve preparation of an EIS that builds upon and incorporates the findings of the PEL review[8].

A Regulatory Roadmap

We have outlined a regulatory roadmap for the Missouri Department of Transportation (MoDOT) to secure approvals from the U.S. Department of Transportation (DOT) to construct a Tubed Transportation System (TTS) national certification track and demonstrate and validate TTS technologies. We also discuss potential funding mechanisms for the certification track. Ideally, the track would be between 12 to 15 miles long, but could be built in phases with the first phase being 3 to 6 miles.

I. Federal Regulatory Approval of TTS

A. U.S. Department of Transportation Regulation of TTS

The Secretary of Transportation is authorized by law to regulate the safety of passenger and commercial transportation as well as the environmental impacts of certain actions.[9] One of the enumerated authorities Congress granted to the Secretary is the authority "to stimulate technological advances in transportation."[10] The Secretary delegates the authority to regulate the different modes of transportation to the modal administrators within DOT. Recognizing that new and emerging technologies like TTS do not fit squarely within the jurisdiction of one modal administration, the Secretary of

[8] From Missouri Feasibility study (cite page #'s)
[9] PL 89-670 (1966)
[10] *Id.* At sec. 2(b)(1).

Transportation established the Non-Traditional and Emerging Transportation and Technology ("NETT") Council in December 11, 2018.[11] The Council is an internal deliberative body tasked with "identifying and resolving jurisdictional and regulatory gaps, including with respect to safety oversight, environmental review and funding, that may impede the deployment of new technology, such as tunneling, hyperloop, autonomous vehicles, and other innovations."[12]

The Council will form working groups that meet at least twice per month. For any project that the Council considers, it will designate a lead mode for safety and environmental review and arrange for the detailing of staff between modes or to the Office of the Secretary as needed to maximize the sharing of experience and expertise. The working groups are required to provide reports to the Chair on the status of their projects.[13]

B. Process for Securing DOT Authorization to Build, Test and Validate TTS

The Council will determine which modal agency is the lead for a TTS certification track. One such possibility is that the Pipeline and Hazardous Materials Safety Administration (PHMSA) could serve as the lead agency in light of its jurisdiction. PHMSA regulates pipeline construction as well as the transportation of hazardous materials. Since the construction of a TTS certification track involves construction of a pipe, PHMSA could model its regulatory approvals after the procedures it uses to set standards for pipelines and inspect them.[14] Likewise, PHMSA's experience regulating transportation of hazardous materials and, in particular, issuance of special permits allowing persons to transport hazardous materials in a manner not authorized under the hazardous materials regulations

[11] https://www.transportation.gov/sites/dot.gov/files/docs/mission/335946/dot-order-112034.pdf,
[12] https://www.transportation.gov/nettcouncil.
[13] The Council held an organizing meeting in March 2019 and is currently reviewing tunneling technologies seeking various approvals in several states. https://www.transportation.gov/briefing-room/dot1019.
[14] 49 CFR Parts 192 and 195.

should be comparable to the type of authorization required to operate the certification track.[15] Since the pipe through which the transportation conveyance would travel is a pressurized vessel, PHMSA would be in a position to consider a special permit application that defined the operating environment and safeguards for the technology.

The Secretary may determine that the Federal Railroad Administration (FRA) is better equipped in light of the fact that it is regulating Magnetic Levitation (Maglev) train deployment, including establishing safety regulations.[16] FRA also regulates rail safety by seeking consensus from industry stakeholders.[17] The Secretary likely will recognize the role of the Federal Highway Administration in regulating the construction of a certification track in highway right-of-way and the Federal Aviation Administration in certifying aircraft, but we expect they would participate in the working group rather than lead it.

Whichever agency or agencies are responsible for permitting the certification track, they should work with university partners and industry to develop standards for testing and validating the technology. Ideally, the University of Missouri should lead a University Transportation Center focused on TTS. Such a Center should be authorized and funded by Congress in the next surface transportation authorization bill or through an appropriation.

C. Environmental Review and Permitting

We would expect DOT to require the certification track to undergo a review of environmental impacts under the National Environmental Policy Act (NEPA). NEPA mandates that environmental impacts be considered before any major federal action likely to significantly affect the environment is undertaken.[18] CEQ

[15] 49 CFR § 107.105. 5117.
[16] 49 CR Part 268.
[17] 49 U.S.C. § 103(g) (authorizing the FRA Administrator to carry out the DOT Secretary's "duties and powers related to railroad safety [and] railroad policy and development"); *id.* § 20102(2)(A) (defining "railroad").
[18] 42 U.S.C. § 4332(C).

has interpreted the statutory definition of "major Federal action" to "include[] actions with effects that may be major and which are potentially subject to Federal control and responsibility."[19] CEQ defines "actions" to include "projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by federal agencies" and provides the example of "[a]pproval of specific projects, such as construction or management activities located in a defined geographic area" as a federal action.[20]

CEQ defines "significantly" both in terms of "context and intensity."[21] With respect to context, an action's significance must be analyzed through multiple frameworks, including "society as a whole (human, national), the affected region, the affected interests, and the locality."[22] "Intensity" refers to "the severity of impact" and CEQ gives a list of factors to be considered in evaluating intensity, such as public health and safety effects, unique characteristics of the project's geographic setting, contentiousness of the project's effects on the environment, and whether the action may establish a precedent for future actions.

If the above threshold requirements are met, the lead federal agency must undertake NEPA review of the project. Even if the project does not secure federal funding, if it requires a permit from the Army Corps of Engineers or another resource agency or if it is viewed as an intrastate pipeline it would require NEPA review and potentially a permit from a resource agency (e.g., the Army Corps of Engineers, Fish and Wildlife Service, State Historic Resource Office if the project has a potential to cause discharges into Waters of the United States or affect endangered species, parkland or historic resources .[23] If the plan is to build the project in an existing right of way, the likelihood for environmental

[19] 40 CFR §1508.18.
[20] Id.
[21] 40 C.F.R. § 1508.27.
[22] Id.
[23] https://openei.org/wiki/RAPID/Roadmap/9-FD-k.

impacts may be reduced. We expect the certification track either would require either an Environmental Impact Statement or an Environmental Assessment.

We also may be able to expedite the project by designating the certification track as a "Special Experimental Project (SEP-15) to Explore Alternative and Innovative Approaches to the Overall Project Development Process.[24] The SEP-15 process is intended to streamline contracting, compliance with environmental requirements, right-of-way acquisition and project finance. The TTS certification track would be a good candidate for SEP-15 in light of its potential transformative impact and could allow the project sponsor to request certain deviations from the project development and implementation process.

The TTS project will need a state or local government or authority to act as the project sponsor. The sponsor must have the authority to acquire property by eminent domain, serve undertake the environmental review process (in cooperation with DOT and federal participating agencies), be empowered to apply for and receive the necessary federal and state permits, issue bonds and have authority to exercise of eminent domain and build and operate a certification track. Of note, the state of Maharashtra in India labeled its hyperloop project a "public infrastructure project" and assigned oversight to the Pune Metropolitan Regional Development Authority. Industry press hailed the news as a clear sign of the importance lawmakers in the state assigned to the project.[25]

II. State Sponsorship of Hyperloop Project

The Blue Ribbon Panel's understanding of relevant state law suggests that there are a number of entities that could serve as the project sponsor, including:

A. A newly formed or existing Transportation Corporation

[24] https://www.fhwa.dot.gov/ipd/p3/toolkit/usdot/sep15/101404_memorandum.aspx.
[25] TechCrunch (July 31, 2019), available at: https://techcrunch.com/2019/07/31/india-has-labeled-hyperloop-a-public-infrastructure-project-heres-why-that-matters/.

B. A Transportation Development District

C. A Special-Purpose Authority

International Collaboration

An option for cost sharing and expedited validation would be for the U.S. DOT to enter into a memorandum of agreement with foreign counterparts in Canada and the EU addressing uniformity of regulations. There are MOU's or other international agreements addressing regulation of pharmaceuticals, energy, ocean transport, aviation, and financial markets, so it would appear that a joint certification could be agreed upon by regulators in the US, EU and Canada.[26] Members of the regulatory working group discussed this possibility with the EU MOVE Directorate as well as Transport Canada. Both entities were open to further exploration of the concept. The Panel believes that international collaboration in the Certification Track would be a significant benefit to the state of Missouri, opening up potential foreign investment in the project.

[26] http://www.nepia.com/insights/industry-news/us-coastguard-memorandum-of-understanding-with-transport-canada/; https://www.ferc.gov/legal/mou.asp; https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwiPkIjhjIDkAhUmmeAKHTknAjsQFjAAegQIABAC&url=https%3A%2F%2Fwww.car-2-car.org%2Ffileadmin%2Fdocuments%2FGeneral_Documents%2FC2C-CC_MoU_on_Deployment_Oct_2012.pdf&usg=AOvVaw2GhPaekrp3Lk8tISYAnLBS.

SECTION 3: Funding and Financing

Overview

The purpose of this document and the study that has gone into it is to report the conclusions and recommendations of the Speaker's Blue-Ribbon Panel on Hyperloop regarding alternatives to fund, finance and deliver the proposed hyperloop system connecting Kansas City, Columbia, and St. Louis.

The Blue-Ribbon Panel was given two objectives:

- Study how various funding and financing strategies for major civil infrastructure projects around the world could apply to building the Virgin Hyperloop One route. Place an emphasis on public-private partnership structures that alleviate risk to taxpayers.

- Determining how to establish Missouri as the global epicenter for research and development of this technology, which would significantly benefit our higher education, logistics, tech, and advanced manufacturing sectors.

After reviewing the technology, costs, benefits and risks of The Missouri Hyperloop Project, the Blue Ribbon Panel recommends that if the Project is built that it:

- Be built in a phased approach, beginning with a certification track, as the surest way to establish Missouri and the United States as the global epicenter for research and development of this and related technology, significantly benefiting our citizens, higher education, logistics, tech, and advanced manufacturing sectors.

- Be built through a public-private partnership that delivers the project in the safest, fastest and most responsible way possible, especially delivering the project benefits and mitigating the risks to taxpayers.

As articulated in this section, we define The Missouri Hyperloop Project as three-phase project:

(1) Create the certification track, (2) Build the commercial route, and (3) Operate the commercial route.

Recommended Approach to Funding, Financing, and Delivery

Our considerations to fund, finance and deliver "The Missouri Hyperloop Project" are based on the specific steps that Missouri has done in the past to create the prosperity Missourians benefit from today.

Now at beginning of the 21st century, we recommend we repeat in principle these actions to create prosperity for the generations to come:

Recommendation #1: Define and organize The Missouri Hyperloop into three phases: (1) Building a National Certification Track, (2) Enabling a partnership to build and operate a commercial hyperloop route connecting Kansas City, Columbia, St. Louis as identified in the Missouri Hyperloop Feasibility Study, and (3) Ensuring capital is reinvested to maintain the commercial hyperloop route,

Recommendation #2: State of Missouri appoints a new or existing entity to serve as the Project Sponsor to oversee the public interest, develop the initial finance plan and procure the private sector partners, all while trying to mitigate risk to taxpayers.

Recommendation #3: State of Missouri explores the creation of a Missouri Hyperloop Corporation to develop a responsible financial plan and procure private sector partners in a delivery model which mitigates the risk to taxpayers**.**

The BRP Approach to Developing these Recommendations

To understand the range of possibilities regarding funding, financing and delivery the Blue-Ribbon Panel's workgroup formulated the following questions at our April 16, 2019 meeting, and our resulting recommendations emerged from the answers. The initial questions logically cluster around three components:

Project-Related Questions

What is the Project Definition?

What are the Project Benefits?

What are the Project Values/Guiding Principles?

What is the Project Timetable?

Are there comparable Projects?

Who is the Project Sponsor?

What are the various project delivery models under consideration?

Financial-Related Questions

What are the Costs?

What are the Potential Sources for Funding?

What are the Alternative Methods for Financing?

Governance and Oversight Questions

What is the public sector risk tolerance?

What are the advantages/disadvantages of various project delivery methods?

What is/are the regulatory framework(s)?

Developed Key Assumptions

The workgroup developed these key assumptions that underpin our recommendations:

- The "Missouri Hyperloop Feasibility Study" by Black & Veatch demonstrates technical feasibility.
- Any commercialization program for hyperloop technology in the United States will first require an extensive research, development, and certification phase, including physical demonstration of the safety and reliability of the underlying technology at a national certification facility.
- Full commercialization is the end goal, though it involves a longer process.
- The primary commercial application for this technology at least initially will be the transport of light cargo.
- Private sector investors have shown interest in similar projects.
- The risks that private sector investors are generally unwilling to absorb are those risks that they are not able to manage and/or mitigate. One such example of a risk that the private sector would not absorb is the risk of public sector uncertainty.
- Current regulatory and legal impediments to construction of a commercial route may be addressed via a combination of legislative action and rule promulgation.

Full commercialization (i.e., the construction of a commercial route connected to the national transportation grid) is the end goal, though it involves a longer process than merely building a Certification Track. When thinking about the likeliest path to commercialization, it is instructive to consider the history of the US space program. The first artifacts that were sent into space were inanimate. Only after the core concepts of achieving escape velocity, maintaining structural integrity, and sustaining orbit were conclusively proven (and demonstrated in reality) did the program begin the process of sending human beings into space. This involved an entirely new set of challenges, including understanding the effects of extra-atmospheric radiation on bodies and, of course, figuring out how to get living creatures back to Earth intact. The first animals in space were fruit flies. Then came dogs and cats; next, monkeys and chimps. Humans came much later[27].

The same principles are likely to apply to commercialization of hyperloop. Before humans begin zipping between cities in near-vacuum tubes at 670mph, an extensive testing and certification process must take place. During this phase of development—which could take as long as 5 to 7 years—we believe that the primary commercial application for this technology will be the transport of light cargo. For Missouri, this means connecting our manufacturing and agricultural output with external markets.

[27] https://www.nationalgeographic.com.au/space/animals-in-space.aspx

The sections that follow provide more detail for each for these three recommendations. Relevant background information is included in the appendices.

Recommendation #1

Define and organize The Missouri Hyperloop into three phases: (1) Certification Track, (2) commercial hyperloop route connecting Kansas City, Columbia, and St. Louis, (3) Operating and reinvesting capital to maintain the commercial hyperloop.

Project Definition

The Project is defined as delivering "The Missouri Hyperloop," the nation's first completed hyperloop system in an envisioned national hyperloop network. The Missouri Hyperloop Project is organized into three phases:

Phase I: Certification Track for International Tube Transport Center of Excellence

We envision an elevated, single-tube Certification Track that ultimately extends to a length of 12-15 miles. A track of this length would represent a significant improvement over currently-operating prototypes.

Based on our research, which includes discussions with tubed transport technology providers as well as a review of studies in Europe, the Middle East, and India, we conclude a track of approximately 12-15 miles would be sufficient for regulatory review and safety certification. The certification track could itself be built in phases, beginning with a roughly three mile segment that would permit initial testing of core technology components. Such a project would represent a significant advance over current beta testing facilities in the Netherlands (30 meters) and Nevada (500 meters).

The essential components of any certification track would include:

- Vacuum tubes
- Pylons
- High speed switches
- Airlocks
- Magnetic levitation and propulsion system
- Guidance system
- Pods
- Portal

The alignment geometry of any certification track is also an important consideration. Aside from the prospective length of the full certification track (anticipated at approximately 12-15 miles), the system should encompass at least one significant curve as well as some variation in elevation.

It should also allow the pods to approach maximum velocity, a key requirement in any certification process. The total cost of a track of this length has been estimated at $300-$500MM USD. Importantly, this initial segment—effectively "Mile Zero" on an eventual national network—would be at least three-and-a-half times longer than any existing prototypes and could be used to further validate the viability of the underlying technology.

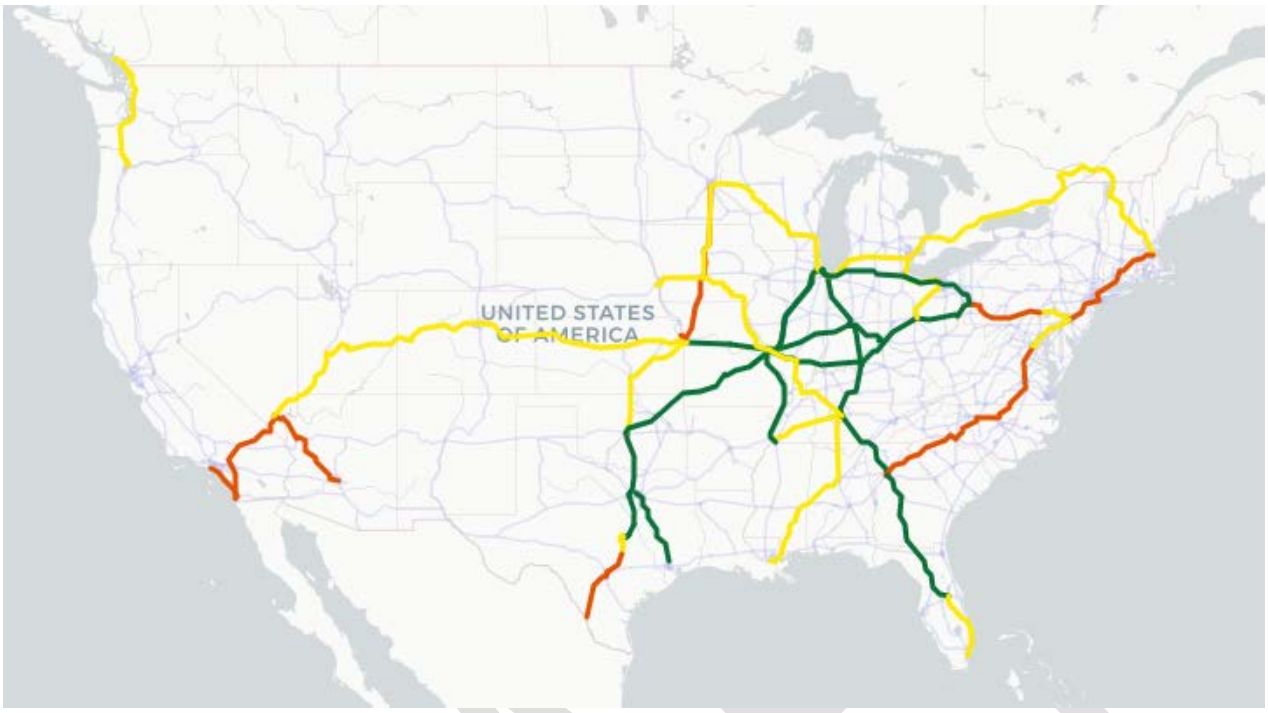
By investing in this initial segment, which we believe could be built according to the regulatory roadmap laid out in Section 2, Missouri would position itself as the natural epicenter for the research, development, and commercialization of hyperloop technology. It is unlikely that other regions would seek to duplicate our efforts, given the cost and complexity involved in initial permitting, regulatory approvals, and construction. Rather, Missouri would be the logical site for continued investment in the track and ongoing evaluation by regulators.

The Panel has concluded that the first site in the continental United States, Canada, or Europe that completes a full-sized segment (~4 meters interior diameter) of tube will likely end up being the beneficiary of future investment. There will be no prize for second place.

Phase II: The Commercial Hyperloop Route in Missouri

The Missouri Hyperloop would become first hyperloop system in the U.S., connecting three Missouri metro areas and the University of Missouri System into a hyperconnected economic megaregion. Hyperloop is a new mode of transportation based on proven science capable of moving freight and people quickly, safely, and directly from origin to destination. The hyperloop connecting Kansas City, Columbia and St. Louis would reduce the current travel time, end-to-end, from around four hours to only 30 minutes, impacting nearly five million people across the state. The estimated cost to build a new hyperloop system across the Missouri ranges from $30 million to $40 million per mile, or approximately $7.3 to $10.4 billion total.

As established in the Missouri Hyperloop Feasibility Study by Black & Veatch the historic Interstate Highway 70 is an ideal corridor for the nation's first hyperloop. At the crossroads of the United States, I-70 connects to six other major interstate highways, links several international airports, and acts as a nexus-placing Missouri talent and business at the crossroads of the world, a new Gateway between the East and the West. It is the birthplace of the US Interstate Highway System, and the natural geopolitical “hub,” to most effectively build out an envisioned national network.



Source: Tube Transport America

Phase III: Operating and reinvesting capital to maintain the Commercial Hyperloop Route in Missouri

The operation and reinvestment phase of the project should be driven by private industry and private capital through a long term concession agreement. The specific terms of that concession agreement would be negotiated on behalf of Missouri taxpayers by the Project Sponsor and would ensure that taxpayers would not be responsible for ongoing maintenance and reinvestment.

Recommendation #2

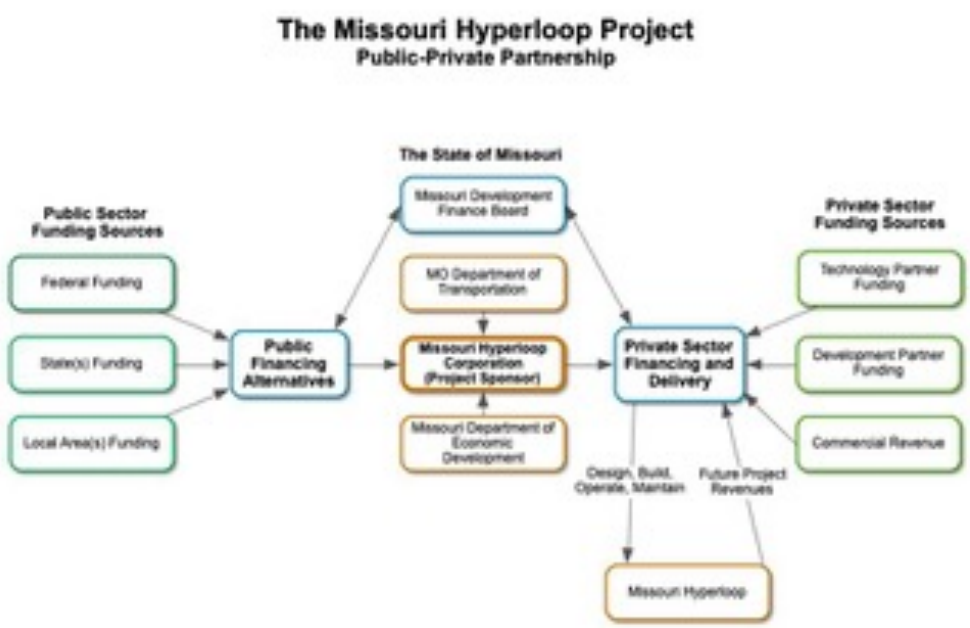
State of Missouri organizes an entity to serve as the Project Sponsor to oversee the public interest, develop the initial finance plan and procure the private sector partners, mitigating risk to taxpayers.

The BRP recommends the state of Missouri repeats the same play by:

1. Organizing an entity to serve as the Project Sponsor. This Project Sponsor would oversee the public interest, develop the initial finance plan, and procure the private sector partners to mitigate risk to the taxpayers.

2. This Project Sponsor, **[which we refer to in this report as "The Missouri Hyperloop Corporation"]**, could be organized and initially staffed by the Missouri Department of Transportation and the Missouri Department of Economic Development.

3. The sole mission of the [Missouri Hyperloop Corporation] is to support the development The Missouri Hyperloop Project. This includes develop the financing plan, work with federal, interstate and local public sector funding and financing, procure private sector partners and oversee the public interest beginning with completion of the Certification Track for International Tube Transport Center of Excellence.



Recommendation #3

State of Missouri explore creation of a Missouri Hyperloop Corporation to develop a responsible financial plan and procure private sector partners to develop a delivery model that mitigates risk to taxpayers.

Developing an Initial Financing Plan

The Missouri Hyperloop Corporation should be able to secure up-front funding and financing capacity. Other critical factors that the Missouri Hyperloop Corporation should be able to complete include:

- The ability to realistically forecast future commercial revenues as one of the sources for repayment of financing

- Deployment of an optimal mix of bankable financing elements
- Retention of flexibility to react to market conditions
- Incorporate commercially viable risk allocation

The Partnership Model

We recommend what we call a “partnership model.”

As defined herein, “the partnership model is a form of project delivery strategy where the design, construction, and operation” of Missouri Hyperloop will be completed by the Technology and Development Partners “for the benefit” of the general public.

“One of the main features of the partnership model is the transfer of financing, project delivery, operation, and maintenance risks to a private sector entity. Hence, both the design risk as well as the construction risk rests with a private sector entity (other than where changes are requested by the public sector). The private sector entity is incentivized to deliver the project on time and to budget, as payment is typically withheld until the facility is operational. The private sector entity assumes responsibility, and therefore the risk, for the integration of all services.” [-- cite the KPMG report.]

Missouri Hyperloop procures a technology partner, who then procures a development partner. Success will be determined by efficient risk allocation, financially viable counterparties, and transparency in decision making.

SECTION 4: Economic Impact and Cost Benefit Analysis

Four and half years ago the Missouri Chamber Foundation published **Missouri2030: An Agenda to Lead,** a bold, 15-year strategic plan to secure the state's place as a global leader in key economic measurements such as workforce, infrastructure, entrepreneurism and business climate. The plan has served as the vehicle to empower Missouri employers from all industry sectors, and every corner of the state, with an agenda that will drive Missouri toward better job creation, wage growth, economic productivity and output.

In the past few years additional focus has been provided by **Missouri Workforce2030** and **Missouri Technology2030**. Later this year, **Missouri Infrastructure2030** will be released. Missouri has a long history as both an infrastructure pacesetter and as a state whose economy has been hurt as other places have gained an infrastructure advantage. Missouri's economy has historically depended on its position as a center-of-the-country logistics hub. In this time of intense state competition and rapid technological transformation, the state's economic future might well depend on the quality of its infrastructure and the innovative vision of its leaders.

As a part of the Missouri Chamber Foundation's broader infrastructure study, this initial research focuses on the potential economic and competitive impact of constructing a "Hyperloop" along the St. Louis-Columbia-Kansas City corridor. A hyperloop is a sealed tube system with little air friction, allowing transportation pods to move at very high rates of speed. The general idea a "vactrain" dates to Robert Goddard in 1904, but more recently has been championed by modern visionaries as the next step in transportation evolution. In March of 2019, the state created a bipartisan Blue-Ribbon Panel of Missouri lawmakers, public officials, and private sector representatives to explore the possibilities of positioning the state as the global epicenter for research and development of hyperloop technology.

A previously released Black & Veatch feasibility study of the proposed route in Missouri has already confirmed the commercial viability of Virgin Hyperloop One technology. The independent and in-depth report confirmed the *"viability of the I-70 based route through an exhaustive examination of the social impact, station locations, regulatory issues, route*

alignments and rights-of-way associated with a new hyperloop system that would connect Kansas City, Columbia and St. Louis."

This Missouri Chamber Foundation supplemental white paper uses the solid foundation provided by the Black & Veatch findings, and examines the impact of constructing and operating a pioneering hyperloop on infrastructure competitiveness, and specifically on the cluster synergies that could be achieved. It also uses the information that is available to roughly estimate some the possible cost benefits of the Hyperloop.

Traditionally a cost-benefit analysis estimates the equivalent money value of the benefits and costs of a specific project. In this case a comprehensive cost-benefit analysis is complicated by the need for specific estimates that are assigned to non-monetary positives and negatives. For instance, the construction of a hyperloop will likely have positive impacts on road safety, reduced emissions, and individual worker and business efficiencies due to time savings. Some rough cost and job estimates are provided in this document, but the focus is on broader economic and competitiveness impacts that mirror the goals of **Missouri2030**.

Recently, significant global research has been devoted to the concept of **Wider Economic Impacts**, where broader costs and benefits can be better included in benefit assessments. The National Academy of Sciences suggests a clear relationship between infrastructure (transportation) improvements and improved economic growth but recognizes specific research conclusions are impacted by the complexity of this interaction. In this case, a first-of-its kind hyperloop creates significant complexity. Nevertheless, there is clear research suggesting that investments in infrastructure yield economic results.

Robert Puentes and Adie Tomer of the Brookings Institution's Metropolitan Policy Program recently reported, "*In the aftermath of the Great Recession, a dramatic change is occurring in how metropolitan areas plan for their future. In these places, a dedicated set of civic, corporate, political and philanthropic leaders are explicitly making the connection between transportation*

planning and investments with economic growth. This is a new form of transportation planning and placemaking that does not leave growth to chance but starts with the overarching economic vision based on a true assessment of their strengths, challenges and opportunities. It represents a deliberate and intentional set of tactics and strategies."

Dr. Paula Dowell, Director of Economics at Cambridge Systematics, has concluded that "strategically, transportation investments succeed in areas where transportation - or its lack - is an identified impediment to development." She questions whether traditional travel time methods are sufficient to demonstrate impact and concludes that the broader impacts of transportation investment can help to shape economies by supporting clusters, increasing productivity, enhancing labor market accessibility, opening new markets and creating supply chain efficiency.

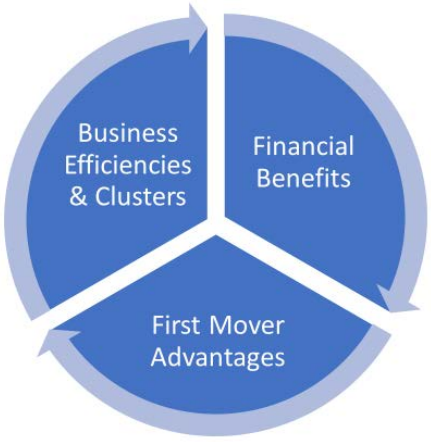
The work by the Brookings team of Puentes and Tomer also suggests that one of the best recent studies analyzing transportation as a way to increase economic growth was a 2008 study by the **United Kingdom Department of Transportation**. It stated that a "well performing transportation network would:

1. **Increase business efficiency**, through time savings and improved reliability for business travelers, freight and logistics operations.
2. **Increase business investment and innovation** by supporting economies of scale or new ways of working.
3. **Support clusters** and agglomerations of economic activity. Transportation improvements can expand labor market areas, improve job matching and facilitate business-to-business interactions.
4. **Improve the efficient functioning of labor markets**, increase labor market flexibility, and the accessibility of jobs.
5. Increase competition by opening up access to **new markets**.
6. **Increase domestic and international trade** by reducing the costs of trading for services and freight.

7. **Attract globally mobile activity** to a region by providing an attractive business environment and good quality of life."

The Missouri Hyperloop has the potential to positively impact each of these areas and each would positively contribute to increased economic growth.

The Chamber Foundation explored the wider economic impacts by focusing on three specific areas: (1) overall business efficiencies and cluster synergies/ enhancements due to increased proximity between St. Louis, Columbia and Kansas City; (2) potential first-mover branding and positioning advantages; and (3) rough estimates of specific financial benefits.



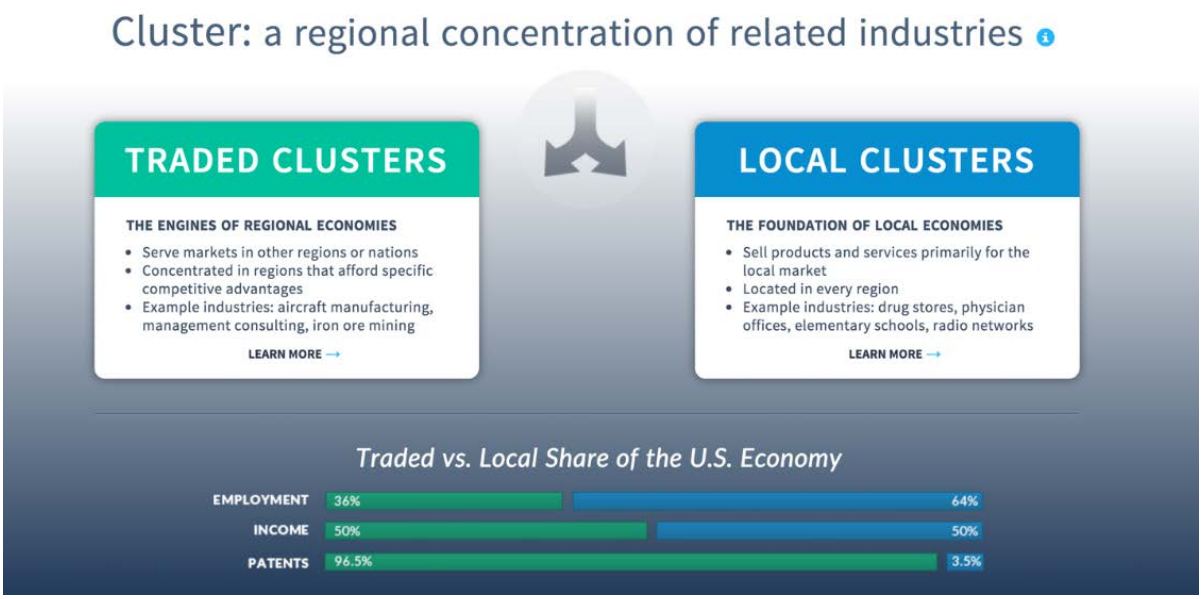
Business Efficiencies and Clustering Impacts

One of the most significant potential competitive benefits of a hyperloop would be better connecting the economies and research capacity of the entire central Missouri corridor. Over 120 years ago a British economist, Alfred Marshall, published a book called *Principles of Economics*, on which much of today's cluster theories are based. He used the term "agglomeration" to explain the geographic clustering of firms, their supply chains and support organizations; and the term "localization effect" to explain how businesses could become more productive (and more competitive) based on external influences.

Three specific impacts contributed to improved competitiveness: (1) input sharing, (2) labor market pooling and (3) knowledge spillover. The Missouri Hyperloop should positively impact each.

A hyperloop connection would effectively eliminate the current distance between St. Louis, Columbia, and Kansas City, creating a super region. If St. Louis, Columbia, and Kansas City were quickly accessible to one another via a hyperloop, the metropolitan areas would have newly proximate supplier networks, labor sheds, and training and research capacity. These components are the building blocks of dynamic industry innovation and growth. To explore the impact of connecting the economies of these three cities we looked closely at the traded clusters of each of the three metropolitan areas and the likely clusters of a geographically connected super-region.

A **business cluster** is a geographic concentration of interconnected **businesses**, suppliers, and associated institutions in a particular field. Traded clusters are groupings of industries that serve markets outside of a region (internationally and/or domestically). Traded clusters often account for less than 40 percent of a region's employment, however, they are usually responsible for 50 percent or more of a region's income and innovation.



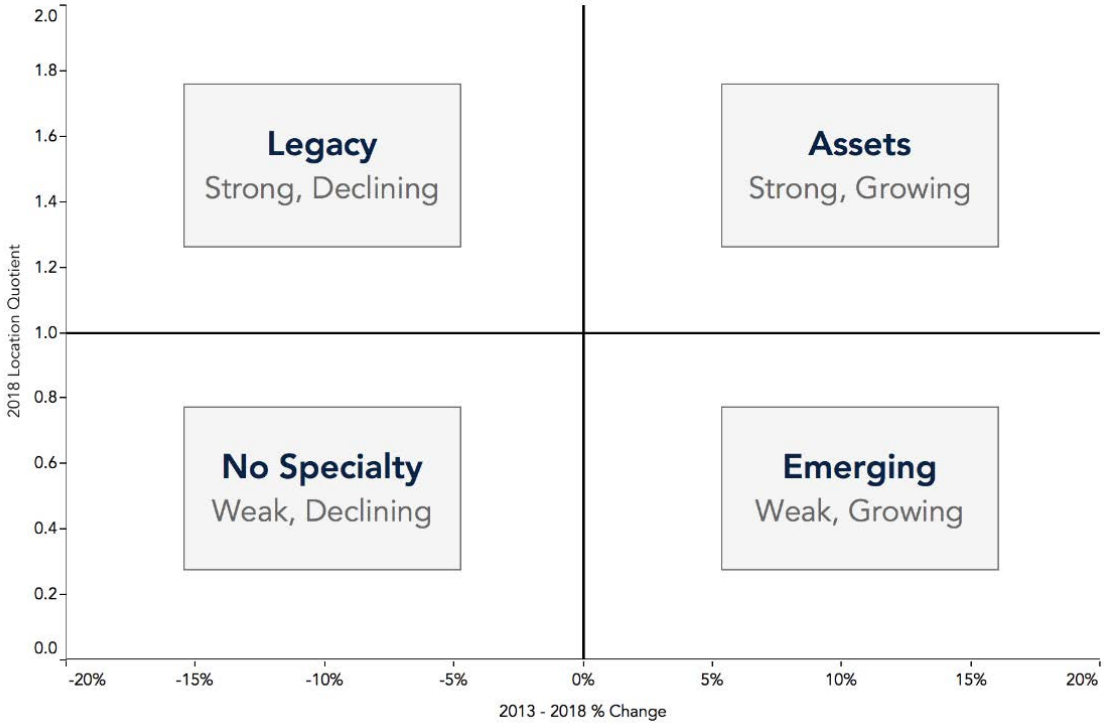
Source: U.S. Cluster Mapping

Positive Impacts of Cluster Input Sharing

If St. Louis, Columbia, and Kansas City were to be made so accessible to one another via a hyperloop, then **input sharing** among companies and their suppliers could occur across the whole corridor. A specialty supplier in Kansas City could easily serve a need in St. Louis.

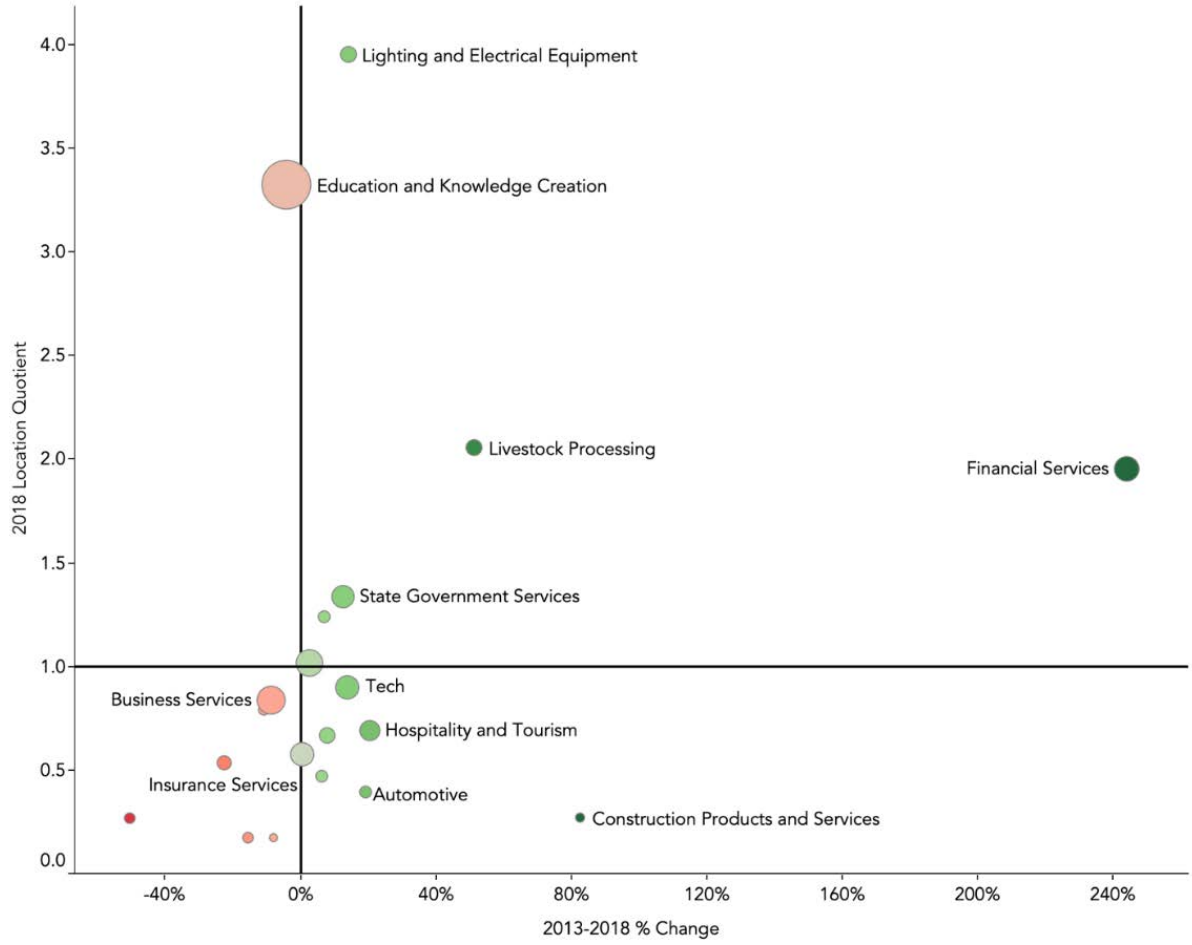
For this analysis, the cluster data for all three cities was reviewed and then analyzed to identify the potential clusters that would be enhanced by input sharing across the super region created by the hyperloop technology. A complete methodology is provided in an appendix. Location quotients (LQs) help demonstrate the clusters that have high concentrations in a region. LQs are the concentration of a cluster's employment in the region compared to national employment levels. A location quotient of greater than 1.00 demonstrates a higher concentration than what would be expected based on national levels. This can reveal what clusters are unique to an area and generating money from outside of the region through exporting. LQs when mapped alongside employment growth can show which clusters are thriving or declining. The chart below demonstrates where a cluster may fall on the map and how it corresponds to its strength and growth.

Example Chart for Cluster Mapping



Columbia's traded cluster workforce is dominated in size by Education and Knowledge Creation due to the presence of the University of Missouri. Jobs in the education and research field are over three times more concentrated in Columbia than the national average. Jobs in this sector have not grown over the last five years. Financial services stands out in the analysis as an asset cluster with tremendous growth in recent years. Other clusters like tech, construction, automotive, and tourism are emerging due to positive growth. Columbia's economy could benefit from hyperloop connection by more easily connecting research from the university to major markets and connecting professional service companies in financial services and tech with a greater workforce pool in St. Louis and Kansas City.

Cluster Analysis of Columbia, Missouri



Source: EMSI 2019.3

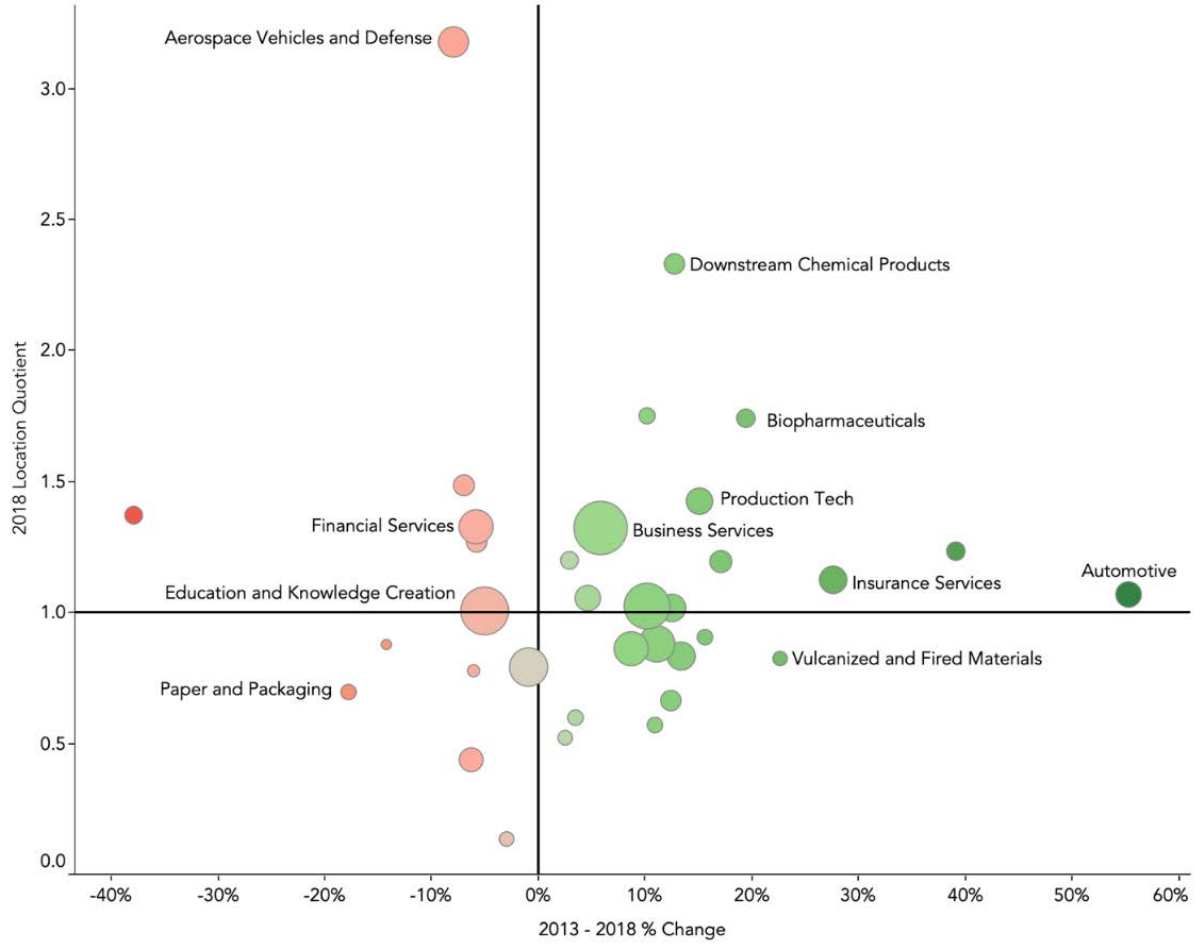
Region: Boone County, Missouri

Note: The size of each circle represents the employment size of each cluster. Clusters with less than 150 employees were excluded from this chart.

The St. Louis region is home to several clusters in advanced manufacturing and professional services. The most concentrated cluster is the Aerospace Vehicles and Defense cluster. This cluster has experienced slight employment decline in recent years but remains a crucial employer providing high earnings. On average a worker in this cluster earns over $150,000 in salary and benefits. Another advanced manufacturing cluster, Automotive, has experienced over 50 percent growth in employment in the last five years. Professional service clusters such as business, insurance, and financial services have concentrations higher than the national average. Many of the clusters that are

successful in the St. Louis region depend on the ability to train and attract highly skilled talent. St. Louis' economy could benefit from a hyperloop connection with a wider workforce pool to recruit specific high-skilled workers. Easier connections with the University of Missouri in Columbia could help facilitate improved and more accessible training resources to develop workers that companies in St. Louis need and to engage students in internships that could increase the chances that they would remain in Missouri after graduation.

Cluster Analysis of St. Louis Region



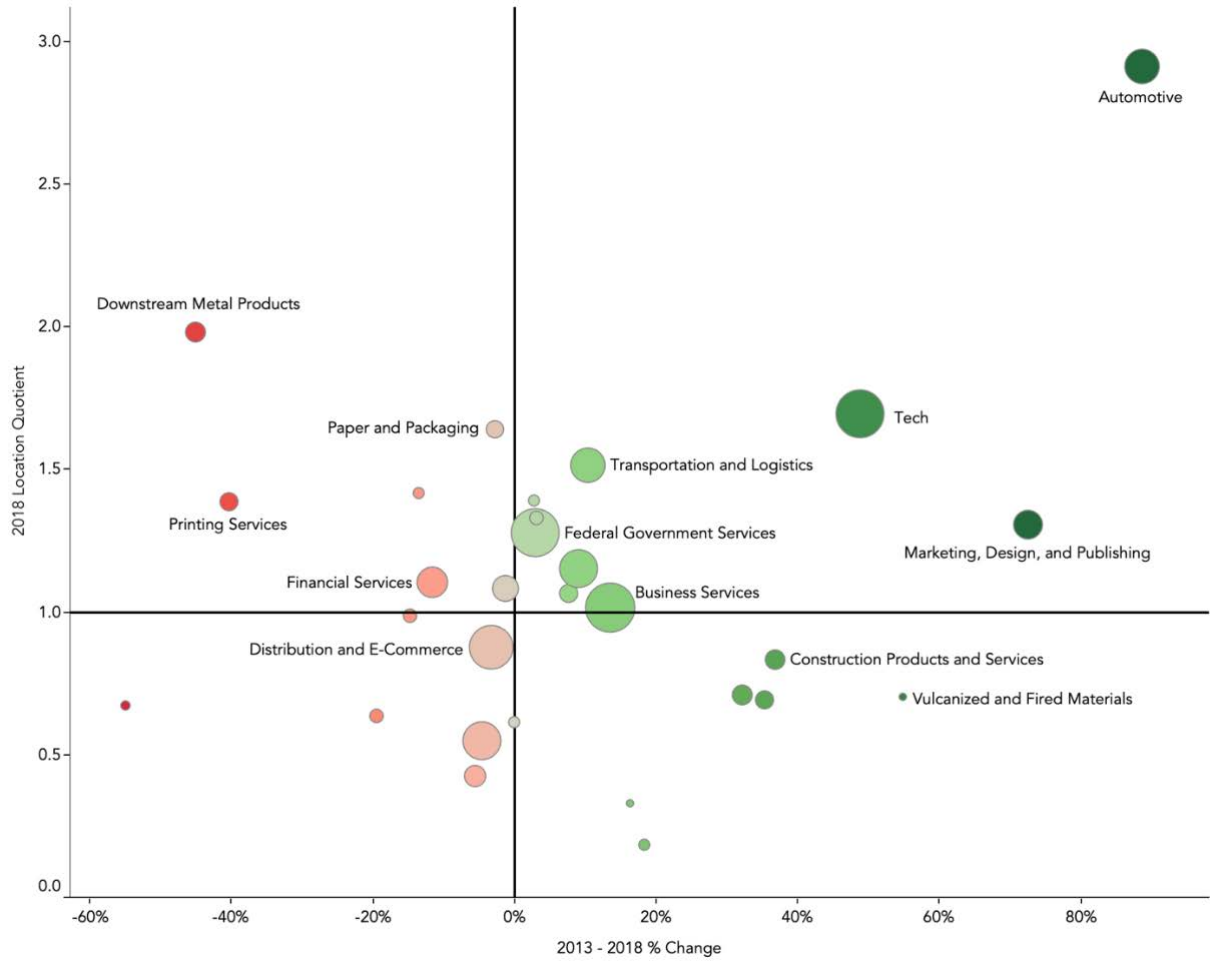
Source: EMSI 2019.3

Region: St. Louis City, St. Louis, St. Charles, Jefferson, Franklin, Lincoln, and Warren Counties

Note: The size of each circle represents the employment size of each cluster. Clusters with less than 800 employees were excluded from this chart.

The most striking cluster from the analysis in the Kansas City region is Automotive. Both Ford and GM have established manufacturing production facilities in the region and both Original Equipment Manufacturers (OEMs) have expanded their operations. In recent years at least 11 suppliers have moved to the Kansas City region. The list of companies involved in this cluster goes all the way to the beginning of the supply chain with the presence of steel foundries. The remaining asset clusters of the Kansas City area include the professional services of Tech, Business, and Marketing Services. Cerner is a large healthcare IT solutions company that is helping drive a tech growth boom in the region. The benefits of hyperloop connection for the Kansas City area also include connections to innovation and training at the university in Columbia and high skill workers from St. Louis. In addition, the asset cluster of Transportation and Logistics could benefit from a new connection to an emerging form of transportation.

Cluster Analysis of Kansas City Region



Source: EMSI 2019.3

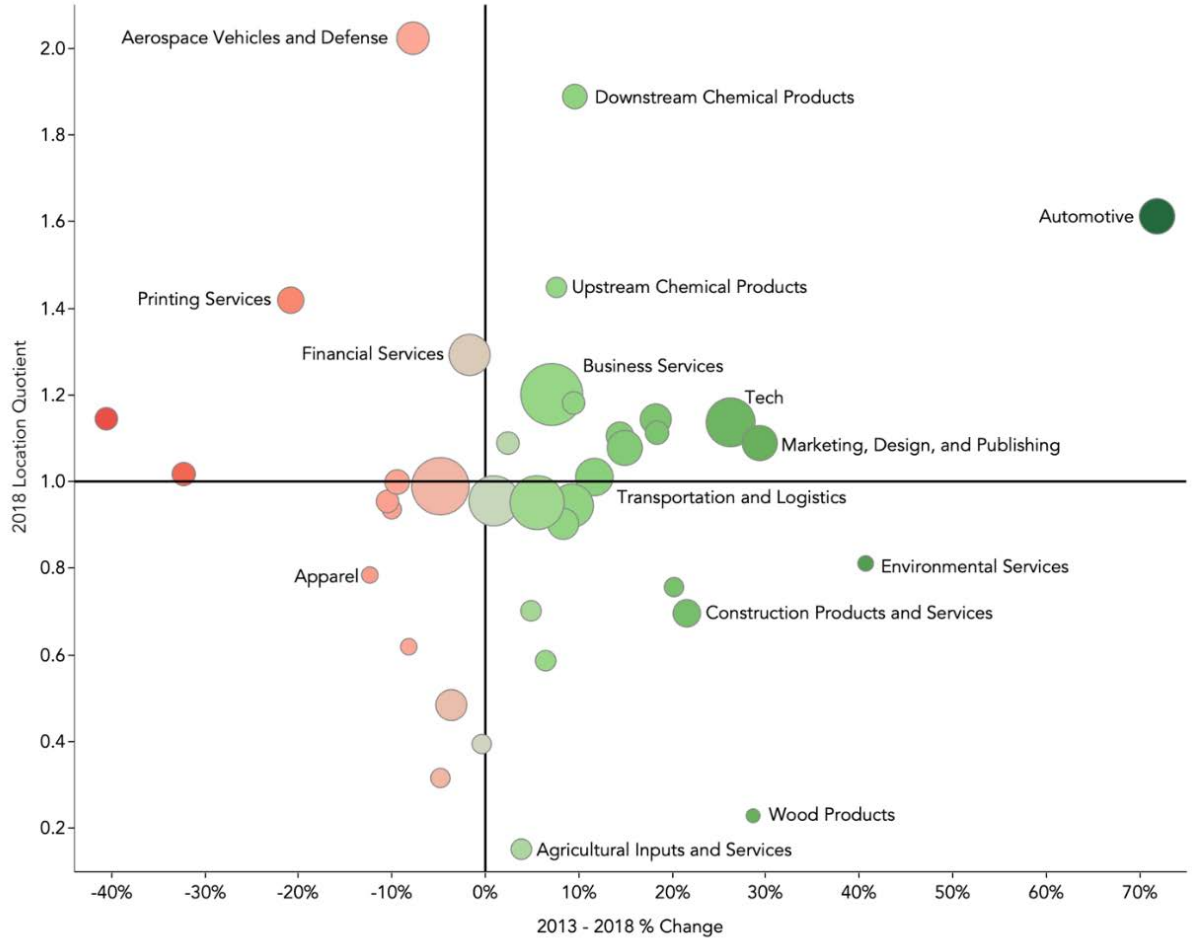
Region: Jackson, Cass, Clay, Platte Counties

Note: The size of each circle represents the employment size of each cluster. Clusters with less than 500 employees were excluded from this chart.

The presence of a hyperloop providing a rapid connection between the three cities, essentially combines their resources and creates a Super Region where input sharing would go well beyond the traditional boundaries created by easy drive time. Some of the highly concentrated clusters in the Super Region come from one contributing source, like St. Louis with Aerospace Vehicles and Defense. Other asset clusters are highly concentrated because there is employment in all three regions, like

Automotive, Tech, and Chemical Products. Quick connections from the hyperloop for workforce and light freight can create efficiencies for the existing clusters. The Automotive cluster, for example, would become more enticing for OEMs and suppliers due to broad input sharing potential.

Cluster Analysis of Super Region

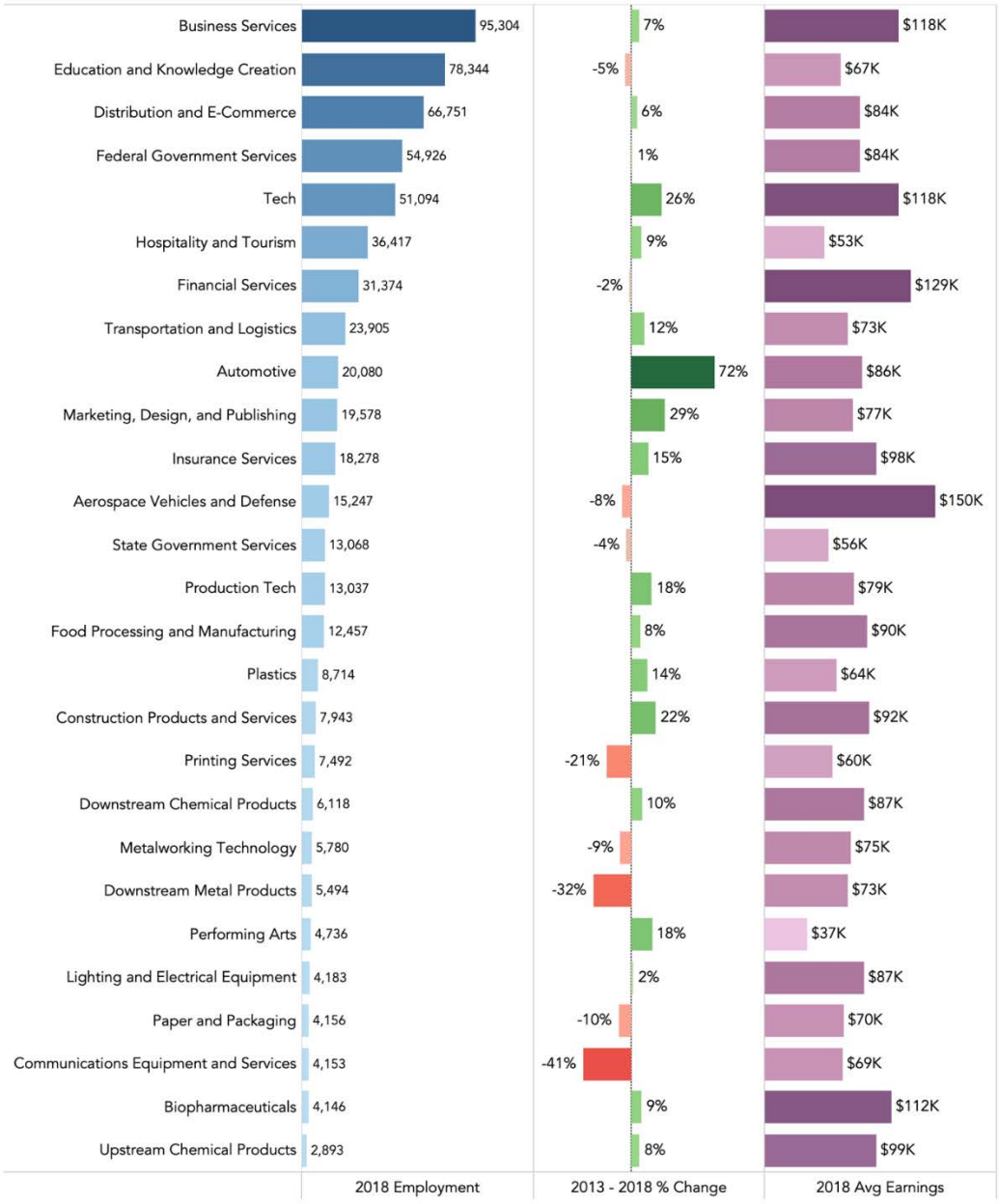


Source: EMSI 2019.3

Region: Columbia, St. Louis, and Kansas City Regions

Note: The size of each circle represents the employment size of each cluster. Clusters with less than 1,000 employees were excluded from this chart.

Top Employing Clusters in the Super Region

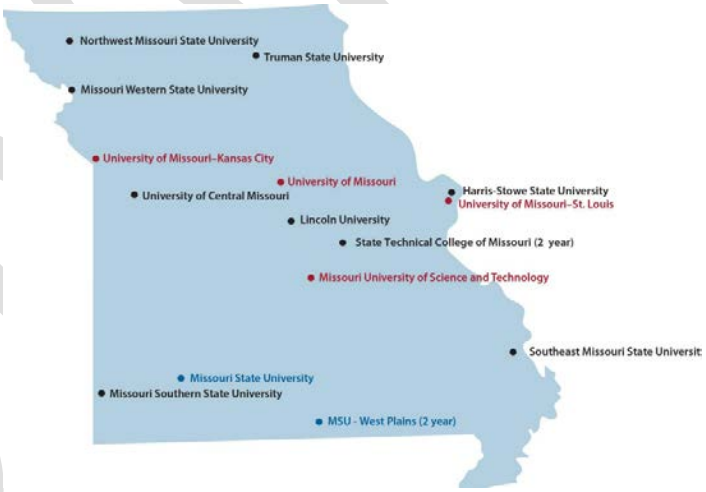


Source: EMSI 2019.3

Positive Impacts of Combined Labor Market Pooling

No issue is currently more important to business success than the increasing challenge to grow and attract sufficient, appropriately trained labor. Both the St. Louis and Kansas City metropolitan areas are among the most populous in the country, St. Louis currently ranking 20th and Kansas City 31st. The large population centers provide each a sizable labor pool to draw from, but each is also experiencing tight labor markets and slow to moderate population growth. National unemployment rates have been near record lows. In the three metros along the proposed hyperloop line the current unemployment rate is well below four percent.

Among the top 100 metros, St. Louis's projected population growth over the next 30 years is ranked 79th fastest and Kansas City's is ranked 51st. The development of a hyperloop would allow workers in either community to easily and quickly commute to work in the other metro and would rewrite the way labor shed research is done. The **labor force pooling** of the three cities would be close to 2.7 million workers, significantly expanding the pool that companies have access to and improving the ranking for site selection purposes to among the top ten in the country.



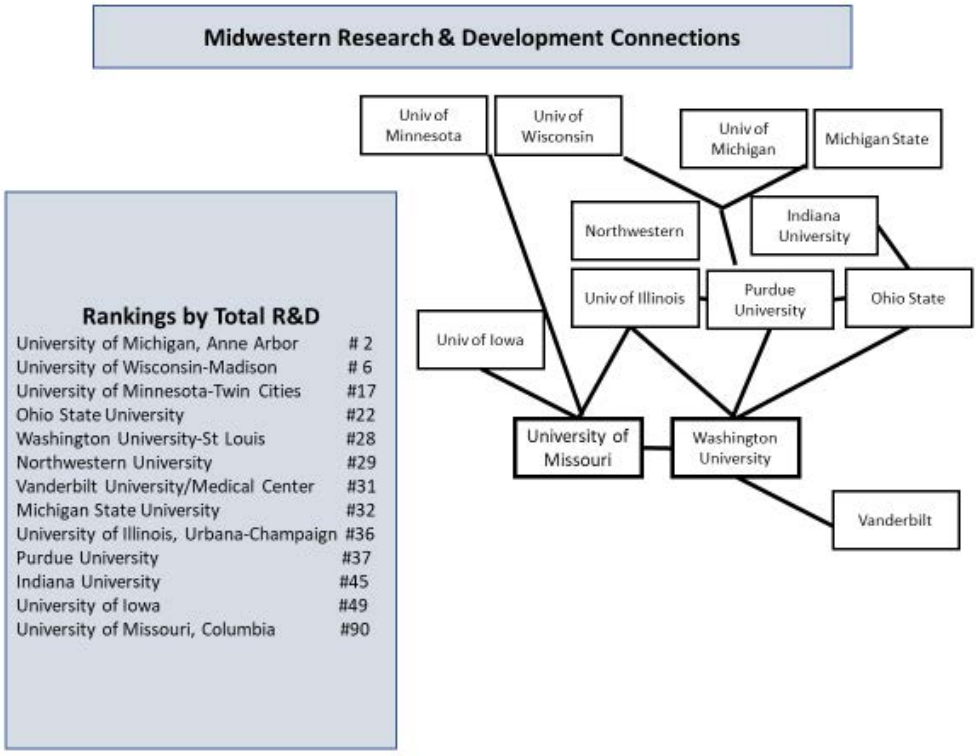
In addition to most employers reporting that they are struggling to find the right quantity of employees, they also often mention quality or specific skills as a challenge. As the skills required to compete rapidly evolve, communities with sophisticated, responsive training and retraining capacity have a significant advantage. Funding duplicate training facilities, especially in fields that require expensive machinery, is always a challenge. Training resources across the corridor would also be available to employees from each metro. Someone needing to upgrade their skills could use a facility across the state on a daily basis.

Positive Impacts of Knowledge Spillover

Research by Dr. Michael Porter and others have demonstrated the undeniable impact of research universities on the economy of their local regions. Porter is quoted as saying, “Colleges and universities harbor large, often untapped revitalization capability for the nation and have the potential, in partnership with governments, businesses, and community organizations, to fuel regional economic growth.” In *Knowledge Spillovers from Research Universities: Evidence from Endowment Value Shocks*, published in The Review of Economics and Statistics, the researchers found evidence that there were knowledge spillovers and demonstratable positive economic impacts. They further concluded that when universities focus on research that is aligned with local business clusters additional benefits can be gained through shared labor markets.

Missouri enjoys two research universities ranked among the top 100 in the country, and several other universities with specialized research, all along the proposed hyperloop corridor. Connecting the assets of all the institutions to businesses across the state would increase **knowledge spillover** and strengthen business.

Again, over time as the hyperloop connectivity expands, Missouri firms can benefit from proximity to a dozen of the top-50 research universities (measured by annual expenditures on research and development) across the Midwest.



Potential Early Adaptor Advantage Impacts

In addition to the many cluster enhancements, a second potential positive derived from the construction of the Missouri Hyperloop would be first, or early adaptor advantage of a new transportation technology. Beginning in the early part of the 19th century, Missouri has been in almost constant competition to position itself as the nation's central logistics hub. The state has been the nexus for the movement of people and goods via wagons, boats, trains, roads and airplanes. But like other competitor states and regions, building and maintaining the right infrastructure at the right time has often challenged civic leaders. Over the past 200 years, having the first, or best, or most affordable ferries, barges, bridges, rail terminuses, interstate connections or airport hubs has consistently defined place-based competitiveness.

Being a pioneer for any new technology always comes with some risk. Realizing the full benefits of the Missouri Hyperloop will require building trust and understanding of the technology with the targeted market. Ultimately success or failure will rest on broader use by individuals and companies. The real

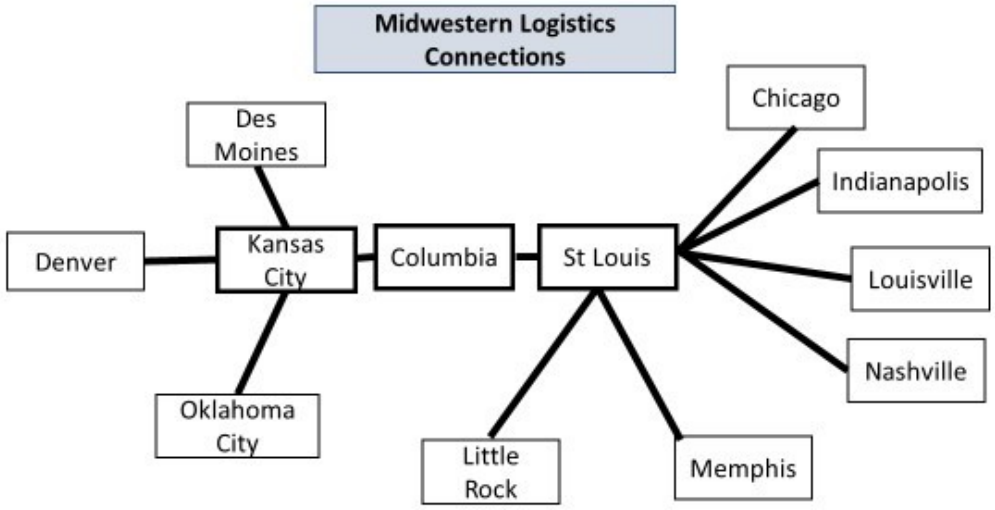
value of enhanced connectivity and time savings should become obvious (and will no doubt be researched) with buildout.

Maintaining and enhancing Missouri's position as a logistics hub will require that state leaders anticipate and prepare for rapid change. *Area Development Magazine*, a must-read for the site selection industry, published some of the changes they expect to impact future logistics hubs. They include:

- Impact of the Panama Canal completion
- Increased shipping to U.S. via Mexican/Canadian Pacific ports
- Greater Intermodal penetration
- Significant increase or decrease in international trade and/or investment
- Growing online retailing
- Low/high fuel cost
- Advancement in big data technologies
- Additive manufacturing (3D printing)
- Drone delivery systems
- Driverless vehicles

Positioning Missouri as the Logistics Hub for the Midwest and Beyond

In subsequent phases, as the hyperloop infrastructure connects Missouri to other potential hubs like Chicago, Memphis, Louisville and beyond, even more synergies are likely to emerge. This could create a Midwest super region that can successfully compete with any region in the world. The logistics hubs currently scattered across the Midwest, when connected, would create efficiencies for all businesses. In a recent article in *Area Development*, Bill Luttrell, Director of Corporate Real Estate for Werner Enterprises, listed both St. Louis and Kansas City as among the country's top logistics hubs, along with other midwestern cities that could be part of a fully connected network.



According to Luttrell, *"Existing logistics hubs and freight corridors are currently attracting the close attention of many manufacturers and warehouse/distribution companies looking for new facilities, and for good reason. The driving force behind this trend is the rising importance of logistics and the supply chain."*

Positioning Missouri as a Technology and Innovation Leader

Missouri is already well positioned as a technology leader. Last year's **Missouri Technology 2030** report highlighted the recent success and bright future for Missouri. The state is projected to be among the top 10 states in technology job growth over the next five years.

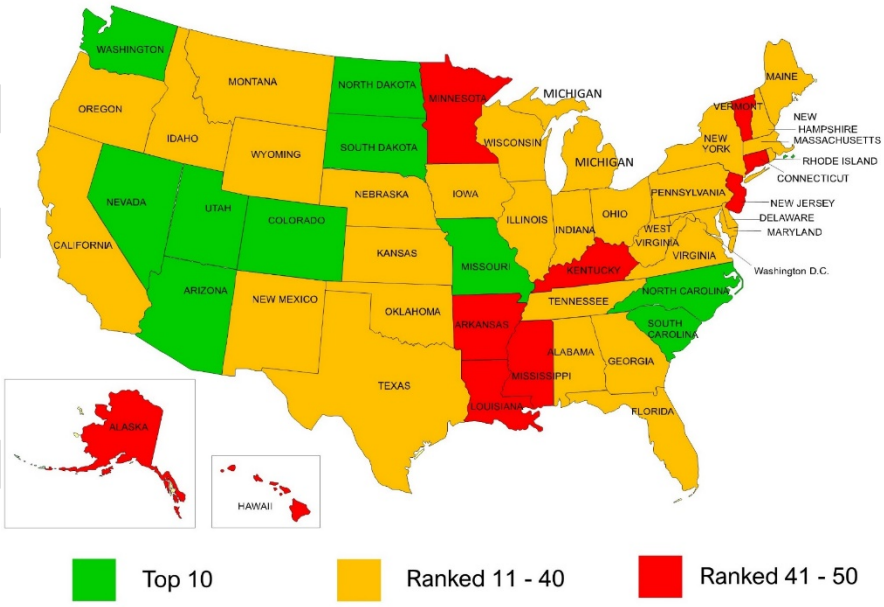


Figure 1-Projected Technology Employment Growth 2018-2023 Missouri Technology 2030

By connecting the business, training and research assets across the central part of the state, technology synergies could create even more success. The review of clusters created by the Super Region shows a potential to

advance the development of several advanced manufacturing and professional services clusters. The Super Region could become a hotbed of research and innovation and could enhance the attraction and retention of highly skilled workers.

The chart below lists the clusters in the Super Region that could benefit from deeper efficiencies and connections made possible by a hyperloop connection. Each offers an opportunity for future economic growth.

Cluster	High Emp	High Concentration	Emp Growth	High Wage
Business Services	X	X	X	X
Tech	X	X	X	X
Insurance Services	X	X	X	X
Financial Services	X	X		X
Aerospace Vehicles and Defense	X	X		X
Automotive	X	X	X	
Transportation and Logistics	X	X	X	
Marketing, Design, and Publishing	X	X	X	
Production Technology	X	X	X	
Food Processing and Manufacturing	X		X	X
Biopharmaceuticals		X	X	X
Upstream Chemical Products		X	X	X
Distribution & E-Commerce	X		X	
Hospitality and Tourism	X		X	
Federal Government Services	X		X	
Lighting and Electrical Equipment	X		X	
Plastics		X	X	
Performing Arts		X	X	
Downstream Chemical Products		X	X	

Construction Products and Services			X	X
Printing Services		X		
Downstream Metal Products		X		
Communications Equipment and Services		X		
State Government Services	X			
Education and Knowledge Creation	X			

Potential Financial Benefit - Considerations and Estimates

At this phase in hyperloop development there are some assumptions that can be utilized to calculate potential financial benefits to the Missouri economy. This paper takes some of the currently available data on hyperloop and conducts basic economic impact analysis. For some impacts EMSI multiplier methodology is used to estimate employment, tax growth and cost savings. Other benefits such as government repair savings, reduced traffic accidents, and emissions reductions offer monetary benefits, but not necessarily new jobs or salaries. Therefore, the multiplying effect of these savings are not calculated. Other benefits where specific data is not yet available were reviewed to provide initial thinking for future potential impacts. Any methodology to calculate impacts is based on a series of assumptions. An explanation of the assumptions and methodology used in this report is included as an appendix.

While these results provide dollar values, hyperloop technology is in an early stage of development. As a new transportation technology, academic literature and data is very limited. The assumptions in these models are based on the best available predictions and are likely to change as the hyperloop technology continues to advance and commercialize. This means the data presented in this section is best used as an understanding of the range and order of magnitude of potential impacts rather than precise measurements. Some of the values in the following charts may not add to the total due to rounding.

Estimated Hyperloop Construction Impacts

The construction of a commercial hyperloop track from Kansas City to St. Louis would bring a large amount of investment and capital into Missouri. While the economic impacts of construction are often viewed by economists as one-time stimulus, the scale of the hyperloop project means that the construction benefits would be experienced over a long time horizon. This analysis provides a low and high range for several of the potential impacts.

Annual Economic Impacts of Low Construction Estimate (million$)

Impact Type	Initial	Direct, Indirect, & Induced	Total
Sales	$525	$443	$967
Earnings	$225	$163	$388
Jobs	2,750	3,510	6,260

Source: EL estimates based on Black & Veatch (2019) and EMSI 2019.3

The low estimates indicate that $525 million would be spent annually in Missouri during hyperloop construction. This investment is calculated to create 2,750 initial jobs. Through supply chain impacts and increased wages, the Missouri economy would create and support another 3,510 jobs for a total of 6,260 annual jobs supported. The total economic benefit to the state is estimated to be $967 million annually for the ten years of construction.

Annual Economic Impacts of High Construction Estimate (million$)

Impact Type	Initial	Direct, Indirect, & Induced	Total
Sales	$901	$772	$1,673
Earnings	$387	$285	$672
Jobs	4,720	6,140	10,860

Source: EL estimates based on Black & Veatch (2019) and EMSI 2019.3

If the construction costs were to realize the high estimates, $901 million would be spent in Missouri annually over ten years. This projection calculates 4,720 jobs in initial investment. Each job created or supported by hyperloop construction would create or support another 1.3 jobs elsewhere in the economy. This results in 10,860 jobs created or supported each year during the construction phase.

The input/output model used also generates an estimate of state, local, and federal tax revenue that would be generated from the investment value. This model predicts the taxes on production and imports that a business might pay given the economic activity associated with the initial change to the economy. At the state and local level, these estimates include non-personal property taxes, licenses, and sales and gross receipts taxes. The predicted annual tax revenue generated for the state government is between $10.5 and $18.7 million. Local governments (city and county entities) across the state would collect between $13.0 and $23.2 million in tax revenue for each year of construction.

Annual Tax Impacts of Construction Estimates (million$)

Tax Type	Low	High
State	$10.5	$18.7
Local	$13.0	$23.2

Source: EL estimates based on Black & Veatch (2019) and EMSI 2019.3

Estimated Hyperloop Operations Impacts

While construction spending impacts would be significant, it would be limited to the construction phase of the project. Once operational, VHO would employ workers to operate and maintain the route. The salaries and supply chain needs for this operation would support other parts of the Missouri economy. This impact is significant in terms of its consistency, producing year after year benefits to the state economy.

Annual Economic Impacts of Low Operations Estimate (million$)

Impact Type	Initial	Direct, Indirect, & Induced	Total
Sales	$12	$10	$22
Earnings	$5	$4	$9
Jobs	150	90	240

Source: EL estimates based on EMSI 2019.3

Based on the ratios of sales and earnings per worker in the Missouri transportation industry, under the Low Operations Estimate, 150 hyperloop employees would create an additional 90 workers in Missouri's economy. The total economic activity generated would be $22 million annually. Using the High Operations Estimate, 300 initial hyperloop employees would spur $44 million in sales annually and 470 workers employed throughout Missouri.

Annual Economic Impacts of High Operations Estimate (million$)

Impact Type	Initial	Direct, Indirect, & Induced	Total
Sales	$23	$21	$44
Earnings	$10	$8	$18
Jobs	300	170	470

Source: EL estimates based on EMSI 2019.3

The operations of the hyperloop would also generate annual tax revenue through sales, property, and income taxes. The state government would generate an estimated annual revenue of $0.2 to $0.5 million in tax revenue annually from the operation of a commercial hyperloop track. Local governments throughout the state would benefit from a range of $0.3 to $0.6 million in new annual tax revenue.

Annual Tax Impacts of Operations Estimates (million$)

Tax Type	Low	High
State	$0.2	$0.5
Local	$0.3	$0.6

Source: EL estimates based on EMSI 2019.3

Estimated Tourism Impacts

Another potential benefit of a hyperloop connection between some of Missouri's major metro areas is increased tourism. With quick travel times, residents may be more inclined to attend events across the state. A visitor to St. Louis from outside Missouri may extend their trip to also see Kansas City because of the convenience of the hyperloop connection, spending more money in Missouri.

The low estimate of positive tourism impact from the hyperloop was measured at a one percent increase in tourism revenues from out-of-state visitors. The high estimate was modeled at a five percent increase. These values are lower than several of the literature review values, to err on the conservative side. Under these assumptions, this would mean an annual increase between $52 and $258 million of tourism revenue in Missouri. Based on the Missouri tourism sector, this would create an initial 800 to 3,980 jobs in the hotel, retail, and restaurant industries.

Annual Economic Impacts of Low Tourism Estimate (million$)

Impact Type	Initial	Direct, Indirect, & Induced	Total
Sales	$52	$46	$98
Earnings	$18	$17	$35
Jobs	800	380	1,180

Source: EL estimates based on EMSI 2019.3 and Missouri Division of Tourism (2019)

The low estimate model predicts an average job multiplier of 1.5, meaning that for every two jobs created in the tourism industry an additional job would be created elsewhere in the Missouri economy. The total economic impact is $98 million in new activity generated annually.

Annual Economic Impacts of High Tourism Estimate (million$)

Impact Type	Initial	Direct, Indirect, & Induced	Total
Sales	$258	$231	$488
Earnings	$90	$86	$175
Jobs	3,980	1,900	5,880

Source: EL estimates based on EMSI 2019.3 and Missouri Division of Tourism (2019)

If the tourism industry experienced a five percent increase in annual revenues from out-of-state visitors, 3,980 new tourism jobs would be created. This would create 1,900 additional jobs elsewhere in the Missouri economy from supply chain needs and increased wages. State and local governments would benefit as well from increased sales, income, and occupancy tax revenue. Under the low estimate state and local governments could increase tax revenue by $2.2 and $2.9 million respectively. If the hyperloop were to generate a five percent increase in out-of-state tourism, state and local coffers could increase by $11.2 and $14.3 million, respectively.

Annual Tax Impacts of Tourism Estimates

Tax Type	Low	High
State	$2.2	$11.2
Local	$2.9	$14.3

Source: EL estimates based on EMSI 2019.3 and Missouri Division of Tourism (2019)

Adoption of Hyperloop Data

The next section of benefits attempts to quantify potential positive externalities associated with the adoption of a hyperloop transportation system. The magnitude of these benefits depends highly on the adoption rate of users from existing transportation methods to the hyperloop. For these benefits, the analysis relies heavy on the ridership estimates from the feasibility study. These numbers are based on Missouri Department of Transportation (MODOT) data of vehicle traveling across Interstate 70 (I-70).

Existing Daily Passenger Trips Via Automobile

Travel Route	Low	High
Kansas City -- St. Louis	12,200	17,300
Kansas City – Columbia	4,600	5,500
St. Louis – Columbia	2,200	3,100
TOTAL	**19,000**	**25,900**

Source: Black & Veatch (2019)

In addition to automobile travel, passenger trips between St. Louis and Kansas City via air (2,000 daily) and Amtrak (750 daily) are also included. According to the feasibility study, there are 21,800 and 28,700 daily travelers using existing transportation systems between the three cities. The feasibility study ranges the adoption of hyperloop transportation between 75 percent and 180 percent of existing levels.

Potential Productivity Benefits

When travel times are reduced, people save time and can use that time more productively. A hyperloop in Missouri could reduce travel time between Kansas City and St. Louis by about three hours, and one and a half hours on trips in and out of Columbia.

The average hourly wage of a worker in the Super Region that works for a traded cluster industry is $35.79.[28] Under the assumption that 60 percent of hyperloop ridership would be utilized by these high-skill commuters, the annual time savings benefit could increase to between $315 million and $561 million.

Another way to view the benefit of time savings is to look at the contribution to gross regional product (GRP). In 2018, the average GRP per worker hour in the Super Region was $51.28.[29] Meanwhile, a worker in a traded cluster industry produces about $85.72 in GRP per hour.[30] Assuming that high wage commuting accounts for 60 percent of ridership and that all workers use 60 percent of their time saved to do productive work at their job, $448 to $798 million in GRP would be generated annually.

Potential Reduction in Highway Accident Impacts

One of the most significant expenses of highway travel on society are traffic accidents. Costs range from repairing car damage to serious personal injuries that require lengthy stays in the hospital. These accidents impact the people involved as well as other drivers who endure delays and congestion associated with crashes. At its worst, highway travel can be deadly. A highway fatality is costly to society through lost wages, funeral costs, and emotional trauma. In 2017 alone there were 126 fatal crashes on Missouri's interstates.[31]

One of the benefits of hyperloop technology is that the enclosure prevents interactions with pedestrians and other transportation modes. The enclosure also secures the pods from weather that causes problems with automobile and airline travel. VHO also believes the company can automate the

[28] EL calculations based on EMSI 2019.3
[29] Ibid
[30] Ibid
[31] MODOT, 2019

operation of pods and hope to eliminate human error. If passengers were to forgo highway travel in lieu of hyperloop, the reduced number of cars on highways should reduce the number of traffic accidents.

The feasibility study provided a general review of potential benefits based on averages of all traffic accidents. This analysis expands detailed traffic accident and accident cost data. There is a wide variety of impacts that can be experienced based on the type of traffic accident. For example, a highway fatality can cost society millions of dollars while a fender bender averages just a few thousand dollars in damages.

Economic and Societal Costs of Interstate Crashes

Crash Type	Interstate Cost Per Crash (2010$)	Interstate Cost Per Crash (2018$)
Fatal	$9,156,500	$10,544,300
Serious Injury	$1,447,100	$1,666,400
Minor Injury	$35,900	$41,300
Property Damage Only	$5,500	$6,400

Source: National Highway Traffic Safety Administration [NHTSA] (2015) and BLS (2019) for inflation adjustment

The highway accident reductions were calculated using the adoption rate estimates from the feasibility study. The feasibility study calculated the ability to reduce existing passenger miles between 1.1 and 1.9 billion.[32] To compare with the crash rate data, this was converted into vehicle miles traveled for a reduction of between 0.9 and 1.6 billion miles. This would result in a reduction of between 847 and 1,564 traffic accidents per year. The reduction in accidents would save societal and economic costs of approximately $95 million to $176 million each year.

[32] Black & Veatch, 2019

2017 Missouri Interstate Crash Data

Crash Type	Total	I-70 Proportion	I-70 Crash Rate Per 100 Million VMT
Fatal	126	30	0.6
Serious Injury	411	97	1.9
Minor Injury	4,174	989	19.5
Property Damage Only	15,634	3,704	72.9
Total	**20,345**	**4,820**	**94.9**

Source: MODOT (2019)

Much of these savings would come from the reduction in fatal crashes by 5 to 10 each year. These savings would be from the reduction of just passenger vehicles from I-70. Later in the report the potential crash savings from freight related highway accidents are reviewed. Depending on the adoption rate of freight on the hyperloop system, the impacts from reduced accidents could be even greater.

Crashes and Costs Avoided from Reduced Interstate Accidents

Crash Type	Crashes Avoided (Low)	Crashes Avoided (High)	Cost Savings (Low)	Cost Savings (High)
Fatal	5	10	$55,320,300	$102,042,800
Serious Injury	17	32	$28,518,400	$52,604,400
Minor Injury	174	321	$7,176,100	$13,236,900
Property Damage Only	651	1,201	$4,135,300	$7,627,900
Total	**847**	**1,564**	**$95,150,100**	**$175,512,000**

Source: EL estimates based on Black & Veatch (2019), MODOT (2019), NHTSA (2015), and BLS (2019)

This analysis shows that if the hyperloop system can be operated safely, there can be significant benefits to society by reducing highway accidents. While advanced technologies generally reduce the potential for error, new technologies can bring their own challenges.

Potential Highway Repair Impacts

By lessening vehicle use of I-70, hyperloop transportation would reduce wear and tear on the roads, create a reduction in repair needs, and potentially save government funding. From 2015-2019, Missouri spent $125 million on road repairs on interstates, about $25 million annually.[33] Given that I-70 accounts for about 24 percent of all interstate travel in Missouri, it was assumed that I-70 requires about $5.9 million each year to keep the road in operational shape. [34]

[33] MODOT, 2019
[34] Ibid

Current Missouri Interstate Repair Spending

5-Year	Annual	I-70 Annual Proportion	I-70 Annual Per 100 Million VMT
$125,000,000	$25,000,000	$5,922,500	$116,600

Source: MODOT (2019)

The reduction in vehicle miles traveled from hyperloop usage of between 0.9 and 1.6 billion miles was used to calculate repair savings. At a rate of $116,600 needed in repair per 100 million vehicle miles traveled, this would result in savings of between $1.0 and $1.9 million annually. Again, this analysis is just from passenger usage of the hyperloop. Reducing the usage of freight, discussed later, would also help create repair savings benefits.

A**nnual Interstate Repair Savings from Hyperloop Passenger Transport**

Repair Savings (Low)	Repair Savings (High)
$1,041,000	$1,920,100

Source: EL estimates based on Black & Veatch (2019) and MODOT (2019)

With less demand for repair from less usage, MODOT and the Missouri government could spend less on repairing I-70. They could take that money and put it into other uses, or they could use the savings to implement more intensive repairs on I-70 or elsewhere in the state. In 2016, over 24 percent of roads in Missouri were in poor condition.[35] It could also mean that for the same level of appropriation, I-70 repair funding could be stretched over a longer period of time. In the long run and at the high adoption estimate, 20 years of funding at current levels could be stretched out over 30 years.

[35] Federal Highway Administration, 2018

Time 20 Years of Current I-70 Repair Funding Would Last Under Hyperloop Scenarios

Low	High
24 Years	30 Years

Source: EL estimates based on Black & Veatch (2019) and MODOT (2019)

Potential Reduced Emissions Impacts

Hyperloop travel is designed to be powered by the electricity grid and have zero direct tailpipe emissions. If passengers were to choose hyperloop travel over motor vehicle or air travel this would result in a reduction of energy use, greenhouse gases (GHGs), and critical air pollutants. These reductions were used to determine the potential savings in healthcare costs, climate change impacts, and energy security.

Potential Health Spending Benefits

Air pollutants can cause adverse health events such as exacerbating asthma and bronchitis. This can send residents to the emergency room or keep them home from work, all of which have economic costs. Using the adoption rates of hyperloop technology and models of the life-cycle emissions of various modes of transportation, the net change in air pollutants was estimated. These results were then entered into a model that calculates the health costs of changes to air pollutants. This resulted in an estimated $163 million to $368 million in reduced healthcare costs within Missouri annually from hyperloop adoption.

Annual Avoided Health Impacts (Low Emissions Savings Scenario)

Health Incident	Nation	Missouri
Mortality	26.7-60.5	19.0-43.0
Infant Mortality	0.06	0.05
Nonfatal Heart Attacks	3.2-29.4	2.2-20.3
Respiratory Hospital Admissions	7.1	4.7
Acute Bronchitis	39.2	27.7
Upper Respiratory Symptoms	714.5	504.3
Lower Respiratory Symptoms	500.0	353.0
Asthma ER visits	14.7	10.4
Minor Restricted Activity Days	19,895	14,197
Work Loss Days	3,342	2,387
Asthma Exacerbations	733.4	517.6
Total Health Benefits (million$)	**$229-$518**	**$163-$368**

Source: COBRA (2018)

Greenhouse Gas Emissions Benefits

While the pollutants measured in the prior section have associated health costs, carbon dioxide emissions have negative social costs that can also be measured. The lifecycle emissions analysis of the hyperloop revealed that there would be greenhouse gas reductions from passenger adoption. By reducing car and airplane usage, a hyperloop would help reduce carbon emissions and the impacts of climate change.

Greenhouse Gas Emissions & Societal Costs Averted- Hyperloop Passenger Travel

Metric	Low	High
Metric Tons of CO_2eq Avoided	292,100	533,200
Social Carbon Savings	$14,856,800	$27,122,400

Source: EL estimates based on Black & Veatch (2019), Chester and Horvath (2008), GCBC (2019), VHO (2019), and EPA (2017)

Potential Energy Security Benefits

Another potential benefit of reduced car usage due to hyperloop adoption could be reduced demand of oil, particularly foreign oil. The reduction in foreign oil imports can help lower the risk of oil disruptions and price shocks. Assuming the average vehicle has an average gas mileage of 24.7 miles to a gallon[36], between 36 million and 67 million gallons of gasoline could be reduced each year of hyperloop operation. On average, a barrel of crude oil yields about 19 gallons of gasoline.[37] It was also assumed that 10 percent of gasoline was sourced from domestic ethanol sources. In 2018, the percentage of net foreign oil imports in the United States was 11.7 percent.[38] Under these assumptions, this equates to 200,200 and 369,400 barrels of foreign oil avoided under current conditions. Based on economic literature that accounts for the disadvantages of foreign oil, this could result in between $6.4 and $11.9 million in savings every year.

[36] Reuters, 2018
[37] U.S. Energy Information Administration (EIA), 2018
[38] EIA, 2019

Annual Energy Security Benefits

Metric	Low	High
Vehicle Miles Saved	892,425,000	1,646,150,000
Gallons of Gasoline Saved	36,130,600	66,645,700
Barrels of Oil Avoided	1,711,400	3,156,900
Barrels of Foreign Oil Avoided	200,200	369,400
Economic Savings	$6,447,300	$11,892,600

Source: EL estimates based on Black & Veatch (2019), Reuters (2018), Brown & Kennelly (2013), EIA (2018), and EIA (2019)

Potential Freight Benefits

VHO has said hyperloop technology is one of the first modes of transportation that has been specifically developed in mind for the passenger instead of freight.[39] However, VHO has prospects for freight transport as well. VHO believes that freight transport via hyperloop would help address consumers' need for same-day delivery and businesses need for efficient and lean warehouses. Given the time savings of a hyperloop trip, freight that is high-value and time-sensitive would be a suitable candidate for hyperloop transport.

While trucking is still a very cost-effective mode of transport at $1.69 per mile[40], airline travel is much more expensive. The average cost ratio of air to truck transport is about 4.7, meaning the average air cost per mile is around $7.91.[41] VHO estimates currently predict a cost per mile for hyperloop freight between $1.40 and $2.80.[42] If the costs end up at the higher end of the spectrum, then hyperloop may not be a more cost-effective transport mode than trucking unless the demand for quick delivery is high. However, in both scenarios, hyperloop is lower than air freight costs per mile. There is just less air freight occurring between the cities than there is commercial trucking.

[39] Construction Week Viewpoint Podcast, 2019
[40] American Transportation Research Institute, 2018a
[41] Bureau of Transportation Statistics, 2018
[42] VHO, 2019

Even so, light freight transported by hyperloop would likely have major benefits to Missouri beyond cost savings. This would include reduced highway accidents, highway repairs, highway congestion, and emissions. For example, in Missouri in 2016 congestion on the national highway system cost the trucking industry over $1 billion dollars.[43] If hyperloop freight transport could reduce this number by any portion there would be significant savings to the logistics industry. Once freight capacity numbers can be calculated, similar analysis to that performed in this study for passenger data can be done with freight data to determine additional impacts.

Potential Tax Benefits from Transit-Oriented Development

When transit connections are built near existing real estate properties, those properties have improved access and connection from the new transit station. Research shows if those nearby communities value the access brought by the transit stop, the area will experience an increase in value. This increase in value often comes in the form of higher home and commercial property values. This increase in property values can increase the revenue governments collect from property taxes. The hyperloop proposed in Missouri would have three portal locations at the Truman Sports Complex in Kansas City, Missouri University Hospital in Columbia, and the St. Louis Lambert Airport.[44] Based on studies of other transportation improvements, the quick access to the hyperloop portals should increase the value of property nearby and help spur new development in the area.

Looking at current median home prices in each of the three metro areas gives some indication of the impacts at the single-family residential level. For example, if the median home price near Truman Sports Complex was similar to the median for the entire Kansas City area, a house near the Kansas City portal might experience an increase in value of $6,120 to $20,400. Since transportation benefits are localized to the particular area near stations, more granular data for each portal location would be critical in creating a total economic impact.

[43] American Transportation Research Institute, 2018b
[44] VHO, 2019

Conclusions

The positive competitive impacts from constructing a Missouri Hyperloop, especially to growing the state's traded industry clusters, will likely be significant. By reducing the geographic separation between Kansas City, Columbia and St. Louis, Missouri businesses will enjoy three specific outcomes that should contribute to improved industry competitiveness: (1) input sharing, (2) labor market pooling and (3) knowledge spillover. Some of Missouri's strong industry clusters would be expected to become even stronger and smaller scattered clusters could strengthen significantly.

The presence of a new infrastructure technology can better position Missouri as the "Logistics Hub of the Nation" and brand the state as an infrastructure and technology leader. Early adopters to new technology always face risk, but laggards seldom gain a competitive advantage.

Calculating the economic impacts of new technologies is based on a significant number of assumptions. There are no currently operational hyperloops at this time that can be studied to determine actual impacts. The economic impacts will include the jobs and increased taxes generated by the construction and operation of the hyperloop. Additional potential economic benefits will likely include: increased out-of-state tourism, increased commuter productivity, reduced highway accidents & fatalities, reduced highway repairs, reduced emissions, improved freight competitiveness, and increased property values and tax revenues.

Appendix A - Methodology Section

Cluster Methodology

To determine the current state of traded clusters of Kansas City, Columbia, and St. Louis we collected employment and wage data for over 680 6-digit NAICS code industries in each of these cities. These industries were then grouped into 53 traded clusters. The cluster groupings are very closely related to those provide by US Cluster Mapping; a project produced by the Harvard Business School. Those cluster groupings have not been updated to reflect the most recent iteration of NAICS codes. Therefore, we used EMSI's conversion of the Harvard clusters using to 2017 NAICS codes. A few tech related sectors were moved from the business services cluster to the technology cluster. The final appendix at the end of this report shows the cluster groupings in detail. These clusters were then evaluated on recent growth, location quotients, wages, and total employment.

Methodology for Economic Impact Calculations

Multiplier Calculations

Multipliers are specific values that measure the ripple or secondary effect of how changes in one industry can influence the broader economy. Economic Leadership LLC utilized multipliers for this study from Economic Modeling Specialist International's (EMSI) licensed software. EMSI produces a social accounting matrix that determines the linkages in purchasing patterns between different sectors of the economy. From this matrix, EMSI creates a proprietary input/output model that can calculate the final equilibrium impacts of a change in a regional economy. The EMSI input/output model has four types of multiplying effects:

1. Initial – this represents the jobs, revenues, and earnings directly related to the project.
2. Direct – these impacts are the first round of impacts to the industry's supply chain due to new input purchases required by the project.

3. Indirect – these impacts reflect the second round of activity when the supply chains stimulate sales within their supply chains.
4. Induced – these impacts are the result of increased earnings and therefore further spending throughout the economy.

Construction Cost Benefits

Base on the data provided in the feasibility study, the construction of the hyperloop track would cost between $7.3 and $10.9 billion. This cost only covers the cost of the track infrastructure and does not include the building of portals, land acquisition, or pod construction. This means that the total construction impacts could be larger than this analysis. The feasibility study also estimated that the track would take 5 to 10 years to complete.[45] The multiplier effects of this construction spending were discussed broadly in the feasibility study. For this analysis, the amount of construction spent within Missouri is estimated and applied to EMSI multipliers to determine the annual impact of the total effects on construction spending.

A timeline of 10 years was chosen for this analysis, this is the higher end estimate of the feasibility study but is consistent with the amount of time needed to build other large infrastructure projects. This timeframe produces an annual construction cost of $730 million and $1.9 billion as the low and high estimates. These costs were split into hard (construction and machinery) and soft costs (engineering, environmental consulting, legal, and insurance services). Hard costs accounted for 75 percent of the costs and soft costs made up 25 percent.

With large construction projects, the local economic impact depends, in part, on the amount of the investment that is sourced from the local region. Earlier this year, Harj Dhaliwal from Virgin Hyperloop One (VHO) stated that for a project in India the company believes that they can source about 70 percent of their construction needs locally.[46] Given the greater regulatory burden of the United States may increase the need for consultants on a hyperloop project, 70 percent sourcing from Missouri was used as the high estimate and 50 percent the low estimate. These sourcing percentages were applied to the machinery and soft costs expenditures. It was assumed that 100 percent of the construction

45 Black & Veatch, 2019

46 Construction Week Viewpoint Podcast, 2019

industry demand would be sourced from within Missouri. These initial impacts were entered into the input/output model for Missouri to return the total economic impacts. Exact local sourcing percentages cannot be known until much later, but these estimates provide a fair range for discussion.

Operations Impact

Data on the operational needs of the hyperloop are less defined than construction needs at this time. VHO has mentioned that the company will look to automate operations as much as possible.[47] While there may not be employees driving the portals, there will likely still be a need for engineers, maintenance, and other staffing personnel in Missouri. To determine the number of initial employees that would be employed by VHO, a study reviewing the economic impacts from a Netherlands test track was used.[48] This study predicted there would be 100 initial workers required to operate a 57 km commercial track with two portals. Assuming that the number of portals influences the number of workers a workers-per-portal estimate was derived from this estimate. The Missouri hyperloop would have three portals and 150 workers using this estimate. This was the basis for the low estimate of the operations impacts.

For the higher operations estimate, Virgin Trains USA in Florida was used as a proxy due to its location in the US and connection with the parent company Virgin. This train system has 3 stops and 316 employees. Based on this data, an initial employment impact of 300 was assumed.

Potential Tourism Impact

Tourism benefits from improved transportation connections are not a certainty. The literature shows mixed results. When smaller towns are connected with larger metro areas, the smaller towns often do not see major tourism increases. However, when large major cities are connected the tourism benefits are more dramatic. The results can also be mixed within the tourism industry. As travel times decrease, some visitors may opt to not spend the night in the city they are visiting and return home.

[47] Black & Veatch, 2019
[48] TNO, 2017

This can have a negative impact on hotel revenues while other tourism industries increase.[49] However, if tourism departments market their regions and the hyperloop connection well, then the tourism industry could experience a net positive impact from overall increased demand. Due to the range of potential impacts in the literature, this analysis models how a conservative increase in tourism would impact the overall economy.

In 2017 the Columbia, Kansas City, and St. Louis regions generated a total of $9 billion in tourism expenditures.[50] Given the region of the economic impact analysis is Missouri, it is critical to remove tourism from Missouri residents as that would not be new economic stimulus to the economy. The substitution effect assumes that residents of a region will spend their money in the state even if they were not traveling. About 57 percent of trips in FY 2018 were made by out of state tourists.[51] Only the out of state tourism revenue was counted as new economic benefit.

Potential Productivity Benefit Impact

This benefit was calculated in the feasibility study by multiplying the average hourly salary of a Missouri worker ($22.18 an hour) by the time savings based on ridership data. The hourly salary serves as a metric of the value of a person's time. This calculation results in an estimate of productive benefits that ranges from $230 million to $410 million annually.[52]

In this report, additional calculations are made to account for the use of the hyperloop by high-skill workers for commuting. The cluster analysis of the new super region shows that a hyperloop connection would allow for high-wage and high-skill industries to source workers from across the three cities. If the hourly wage of a commuter is higher, then saving time via hyperloop travel would produce a larger time savings benefit.

[49] Blanquart and Koning, 2017

50 Missouri Division of Tourism, 2019

51 Ibid

[52] Black & Veatch, 2019

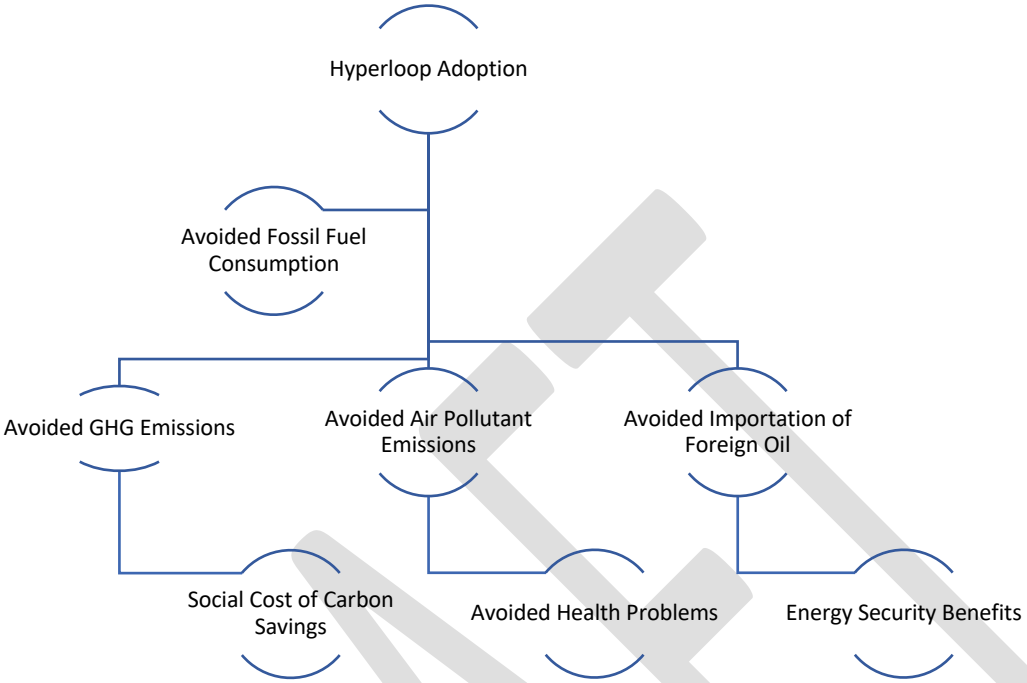
Potential Reduced Emissions Impact

If passengers were to choose hyperloop travel over vehicle or air travel this would result in a reduction of energy use, greenhouse gases (GHGs), and critical air pollutants. Vehicle and air travel emit several pollutants that contribute to air pollution, acid rain, visibility impairment, surface water pollution, and climate change. Hyperloop technology operates on electric power and removes the need for a combustible fuel in operations, thus reducing emission of air pollutants.

Hyperloop travel would still have emissions associated with its operation and development, this would be through the sourcing of fuel to power the electricity grid, construction of the structure, and more. For this reason, this analysis looks at the emissions of transportation through the life-cycle lens. Life-cycle assessments (LCA) measure the emissions from all phases of an operation. For transportation methods this includes "design, raw materials extraction, manufacturing, construction, operation, maintenance, and end-of-life" impacts.[53] Using LCA provides a comprehensive comparison between the emissions of hyperloop and other modes of transportation.

[53] Chester and Horvath, 2008

Methodology for Hyperloop Emissions Benefits



For this comparison, data from the UC Berkeley Center for Future Urban Transport was used that compared the LCA emissions of pollutants from automobile, bus, rail, and air travel. The data in this study is from 2008 and it is very likely that all forms of transportation have become more efficient. However, since it is the net difference in emissions that drives this analysis, it was assumed that all transportation modes reduced their emissions equally during this time and therefore the net change results would be the same.

The level of hyperloop emissions was established by taking the UC Berkley estimates of rail emissions and deducting them based on the lower energy requirement per passenger mile expected from VHO. Rail has similar lifecycle impacts to hyperloop due to the need to construct large concrete structures for the railcars or pods to travel. In fact, construction was one of the major contributors to rail LCA emissions per passenger mile. The Green Line of Massachusetts was chosen as a proxy for the hyperloop for the emissions analysis. This is because at the time of the UC Berkley study about 80 percent of Massachusetts electricity came from fossil fuels, a fuel mix that is equivalent to the current Missouri electricity grid.

The Green Line train system has an operational energy use of 0.9 megajoules per passenger mile. Based on communications with VHO, hyperloop travel is expected to have an operational energy requirement of about 0.4 megajoules per passenger mile.[54] The operational emissions of the Green Line were then converted using this ratio to determine the operational emissions of hyperloop travel. The remainder of the non-operational emissions (construction, manufacturing, etc.) were considered to be the same as the Green Line train for hyperloop. The hyperloop was estimated to have lower emissions in almost every category. A notable exception is sulfur dioxide (SO_2) emissions. This is largely due to the electricity requirements that would be satisfied mostly from coal based on the Missouri electricity fuel mix.

Life Cycle Emissions of Various Modes of Transportation Per Passenger Mile

Metric	Unit	Sedan	SUV	Pickup	Rail	Air	Hyperloop
Energy	MJ/PMT	5	6	8	2.3	3.0	1.8
GHG	g/PMT	360	430	500	220	210	155
CO	mg/PMT	12,000	13,000	16,000	720	550	644
SO_2	mg/PMT	480	470	530	1,200	140	806
NO_x	mg/PMT	1,000	1,000	1,400	410	670	324
VOC	mg/PMT	1,300	1,300	1,600	130	72	125
PM_{10}	mg/PMT	780	720	850	65	32	61

Source: Chester and Horvath (2008) and EL estimates based on VHO (2019)

Based on these LCA emissions rates, the ridership data from the feasibility study informed the calculation of current annual baseline emissions using vehicle, rail, and air travel. The breakdown of sedan, SUV, and pickups was calculated using current auto sales data.[55] Then the hyperloop emissions

[54] VHO, 2019
[55] Good Car Bad Car (GCBC), 2019

numbers were subtracted from the baseline scenario to determine the amount of emissions that would be avoided annually.

To estimate how the emissions reductions created from hyperloop usage could affect health care costs, the US EPA's Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) model was used. The model takes research on the relation between air pollutants and adverse health impacts and converts this to health care costs. The COBRA model produces its own low and high estimates, therefore only the low estimate of averted pollutants was input into the model. The 2017 model year for Missouri highway vehicle emissions was used as the baseline. A conservative 7 percent discount rate was chosen for the health care costs.

Short Tons of Life Cycle Air Pollutants Averted from Hyperloop Passenger Travel

Pollutant	Low	High
$PM_{2.5}$	1,131	2,089
SO_2	-449	-793
NO_x	936	1,698
NH_3	--	--
VOC	1,442	2,663

Source: EL estimates based on Black & Veatch (2019), Chester and Horvath (2008), GCBC (2019), and VHO (2019)

Note: NH_3, ammonia, is an input to the COBRA model, but was not estimated in the life cycle emissions analysis and therefore not utilized in this study. There may be NH_3 emissions benefits from hyperloop adoption.

Potential Health Spending Benefits

Despite creating a net increase in SO_2, the other emissions reductions of hyperloop travel create a net reduction of air pollutants. The cleaner air created in the hyperloop scenario prevents mortality, hospital admissions, and other negative health impacts. As air pollution can travel across state lines, COBRA estimates emission benefits in nearby counties relative to the initial impact. This means that

some of the modeled health benefits are experienced in counties outside of Missouri. For the purposes of this study, the raw data was summed across only the Missouri counties to determine the health benefits achieved within the state. This results in an estimated $163 million to $368 million in reduced healthcare costs annually from hyperloop adoption.

Potential Greenhouse Gas Benefits

The low emissions scenario of this report estimates an annual GHG reduction that would be the same as removing 1,590 railcars of coal from the electricity system or the same savings as operating 62 wind turbines.[56] The US EPA created a measure of the social cost of carbon that can be measured per metric ton of CO2 or CO2 equivalent. This is a measure used by the government to understand the total cost of policy decisions. According to the EPA, the social cost of carbon is "a comprehensive estimate of climate change damages and includes changes in net agricultural productivity, human health, property damages from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning."

While the EPA's estimate includes many types of damages caused by climate change the IPCC Fifth Assessment stated that there are impacts that would increase damages that are not included in the EPA estimate. This means it is potentially a conservative estimate on the impact of carbon emissions. The 2020 social cost of carbon value was used at the 3 percent discount rate. In 2007 dollars, this value was forecasted at $42 per metric ton of carbon emission, or about $51 in 2018 dollars.[57] This value was used to determine the societal costs avoided from climate change impacts from hyperloop usage.

A hyperloop in Missouri could also be beneficial under a future carbon pricing scenario. If the US government were to approve a carbon fee and dividend scheme, gas prices and airline tickets would rise due to their reliance on fossil fuels, while hyperloop travel would be less affected because the lower energy required to operate. Missouri would benefit from having a low-carbon transportation system that would be able to keep costs low for users. Missouri might experience an easier transition to lower carbon transportation with a hyperloop track already in place.

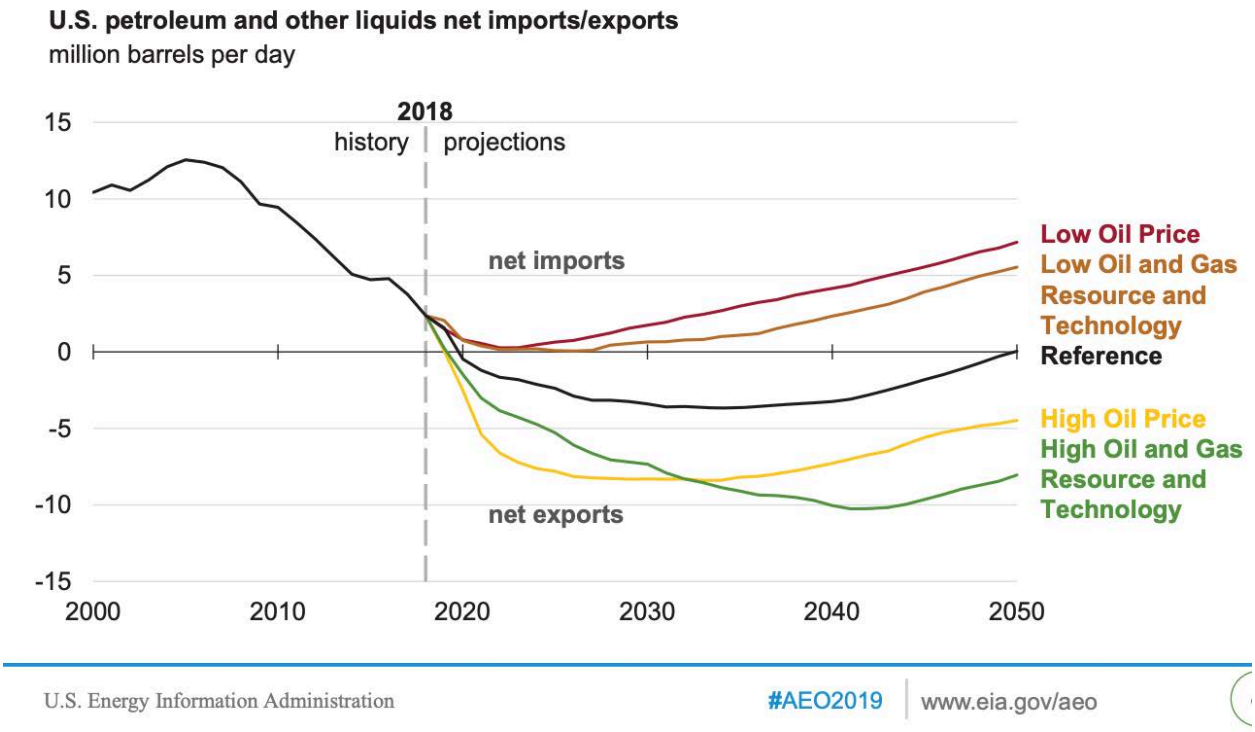
[56] EPA, 2018
[57] EL calculations based on EPA (2017) and BLS (2019)

Potential Energy Security Benefits

Importing foreign oil has negative economic costs including reliance on a monopoly power (OPEC), supply disruptions, government spending to reduce foreign supply, limitations on foreign policy and international alliances, etc. While not all of these impacts can be measured, the National Energy Policy Institute estimated some of these impacts to have an economic cost of $27.96 per barrel of imported oil in 2010 dollars.[58] When converted to 2018 dollars, this cost is about $32.20 per barrel of foreign oil.[59] This analysis only looks at vehicle reductions, it could also be assumed that there would be some energy security benefits derived from the reduction in jet fuel from the transition of air travel to hyperloop.

An important caveat with energy security benefits is the recognition that the rate of net foreign oil imports drives these savings. Under current conditions, the United States is still a net importer of petroleum. However, this rate has been dropping steadily in recent years. This is driven by increased domestic production and exports. The current rate of net petroleum imports of 11.7 percent is one of the lowest levels since 1957. The EIA currently predicts that the United States could become a net exporter of petroleum by 2020.[60] If this were the case by the time a hyperloop was constructed than the energy security benefits would be nonexistent. However, this is a volatile market and predictions can change quickly. Under current estimates, if the price of oil stays low, net foreign imports could increase over the next thirty years. Just five years ago, the EIA thought the net foreign import rate for 2018 would be 34 percent.[61] True energy security benefits during hyperloop operation will depend on real time information on net foreign imports.

[58] Brown & Kennelly, 2013
[59] BLS, 2019
[60] EIA, 2019
[61] EIA, 2013



Source: EIA (2019)

Note: The y-axis of this chart is in net barrels per day and not as a percentage of net imports/exports as is discussed in this analysis.

Potential Freight Benefits

Currently the VHO system is designed to carry packages and palletized freight, but not shipping containers and other heavy freight.[62] VHO was unable to provide an estimate of the capacity of freight that could be adopted from current light freight methods such as trucking and aircraft travel. Therefore, the potential for freight capacity and associated benefits are reviewed in this section, but no calculations are made for economic benefits.

[62] VHO, 2019

VHO system will have a total capacity of 570 pods per hour.[63] The daily ridership estimates from the feasibility study were estimated between 16,350 and 51,660 passengers.[64] Assuming 12 hours of operation in a day and 28 passengers per pod, this results in an hourly need of 49 to 154 pods for passenger travel. This leaves 521 to 416 pods an hour for freight transport.

Missouri Intrastate Freight Flows, 2011

Mode	Tons	Value (million$)
Air	370	$100
Rail	2,436,087	$1,616
Truck	105,627,915	$62,346
Water	4,941,503	$117
Total	**113,005,875**	**$64,179**

Source: MODOT (2017)

Based on MODOT estimates from the feasibility study, there are 19,000 commercial truck trips on I-70 per day.[65] What is unknown about these trips is the number of trucks traveling through the state and those transporting just between Kansas City, St. Louis, or Columbia. In 2011, about 46 percent of all truck freight tonnage passed through Missouri.[66] It is probable that trucks on I-70 would be even more likely to pass through than the state average and the passenger average. Another missing piece of data is the type of freight carried by those trucks traveling within the hyperloop corridor. As the hyperloop cannot accommodate shipping containers, it would be unable to accommodate a portion of trucking freight.

[63] Ibid
[64] Black & Veatch, 2019
[65] Ibid
[66] MODOT, 2017

As for freight transported via airplane, intrastate air freight in 2011 was valued at $100 million and weighted 370 tons.[67] Given that there is only one other small airport in the state for air freight outside of Kansas City and St. Louis, if 85 percent was assumed to be between MCO and STL airports that would amount to 315 tons transported annually. The max weight of a Boeing 737 for freight is about 22.5 tons.[68] Assuming the planes were filled to maximum capacity, there would be about 14 fully weighted freight flights between MCO and STL each year. The missing data for air freight is the adoption rate to hyperloop technology. It's likely that hyperloop will offer many benefits compared to air travel between the two locales including speedier travel and lower costs.

Freight Cost per Mile by Mode of Transportation

Mode	Low	High
Air	$7.91	
Truck	$1.69	
Hyperloop	$1.40	$2.80

Source: American Transportation Research Institute (2018a), Bureau of Transportation Statistics, (2018), and VHO (2019)

Information still needed to complete a freight economic benefit analysis:

- Volume/weight each pod can carry
- Percentage of trucks traveling between Kansas City-Columbia-St. Louis along I-70
- Percentage of trucks carrying packages and palletized freight along I-70
- Value of time for light freight being transported
- Air freight adoption rate
- LCA emissions (GHG, PM, CO, NO_x, and SO_2) per ton-mile of hyperloop and other current modes of transportation

[67] MODOT, 2017
[68] Smithsonian National Air and Space Museum, 2016

Possible Benefits from Transit-Oriented Development

The literature shows varied results when it comes to changes in property values near transportation connections. In a review that analyzed eight prior studies that measured the impacts of being located near passenger rail stations, researchers found that most neighborhoods near these stations experienced increases in property values. The range of positive impacts from the studies reviewed included property value increases nearby between 3 percent and 15 percent. Within some of the studies reviewed there were mixed results, the researchers determined that the most important factor for positive property values impacts was a community that valued the access brought by the transportation connection.[69]

The Diaz paper only reviewed results in the US from 1972-1996, for international and more recent impacts, high-speed rail impacts on property values were also reviewed. Across Europe and Asia where high-speed rail have been built in recent decades, most of the studies of property values have shown increases between 3 to 43 percent.[70] A few studies showed some areas experienced negative impact to property values if the stations were not strategically located or perceived as a nuisance. Nuisance was an important part of each study. If there was nuisance associated with the station being located nearby with noise or crowding, then sometimes the properties in very close proximity saw negative impacts on their property values. Meanwhile, areas a bit further removed from any nuisance experienced an increase in property values.

The highest impact across all studies was in Lyon with the creation of Part-Dieu. The high-speed rail link was developed alongside other major real estate developments to create a new city center. This "well-timed" development led to the highest increases in property values.[71]

Given the leap in time reduction provided by hyperloop transport and its place as a cutting-edge mode, it is likely that the areas near the portals would experience positive benefits. Based on the literature it seems reasonable for the areas near the portals to experience benefits somewhere between 3 percent and 10 percent within three miles of a portal.

[69] Diaz, 1999
[70] Man and Mok, 2016, Bohman and Nilsson, 2016, Hensher, Mulley, and Li, 2012
[71] Hensher, Mulley & Li, 2012

The best method for calculating the impact on property values would be to measure the property values within a three-mile radius of each portal location. Given the complex nature of city and county boundaries in these areas of Missouri, the three portal locations exist within three different counties and nine different city jurisdictions. Potentially this data exists within GIS departments at these different entities. At the time of this study, this data was not readily available, and the increase in total property values or the potential increase in property taxes were not calculated. Median home prices for each metro region were used to demonstrate how impacts could look at the individual property level.

Median Home Prices for Metro Regions Along Hyperloop Route, 2018 Q4

Portal Region	Median Home Price	Low	High
St. Louis	$174,000	+$5,220	+$17,400
Columbia	$186,000	+$5,580	+$18,600
Kansas City	$204,000	+$6,120	+$20,400

Source: EL estimates based on National Association of Realtors (2019)

Information still needed to complete a transit-oriented real estate benefit analysis:

- Total value of property within 3 miles of each portal location
- Property taxing structures of each city and county government that falls with radius of portal locations

Cluster Details

Industry	Traded Cluster Grouping
Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	Aerospace Vehicles and Defense
Aircraft Manufacturing	Aerospace Vehicles and Defense
Aircraft Engine and Engine Parts Manufacturing	Aerospace Vehicles and Defense
Other Aircraft Parts and Auxiliary Equipment Manufacturing	Aerospace Vehicles and Defense
Guided Missile and Space Vehicle Manufacturing	Aerospace Vehicles and Defense
Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	Aerospace Vehicles and Defense
Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	Aerospace Vehicles and Defense
Crop Production	Agricultural Inputs and Services
Animal Production	Agricultural Inputs and Services
Cotton Ginning	Agricultural Inputs and Services
Soil Preparation, Planting, and Cultivating	Agricultural Inputs and Services
Crop Harvesting, Primarily by Machine	Agricultural Inputs and Services
Postharvest Crop Activities (except Cotton Ginning)	Agricultural Inputs and Services
Farm Labor Contractors and Crew Leaders	Agricultural Inputs and Services
Farm Management Services	Agricultural Inputs and Services
Support Activities for Animal Production	Agricultural Inputs and Services

Nitrogenous Fertilizer Manufacturing	Agricultural Inputs and Services
Fertilizer (Mixing Only) Manufacturing	Agricultural Inputs and Services
All Other Miscellaneous Textile Product Mills	Apparel
Cut and Sew Apparel Contractors	Apparel
Men's and Boys' Cut and Sew Apparel Manufacturing	Apparel
Women's, Girls', and Infants' Cut and Sew Apparel Manufacturing	Apparel
Other Cut and Sew Apparel Manufacturing	Apparel
Apparel Accessories and Other Apparel Manufacturing	Apparel
Iron Foundries	Automotive
Steel Investment Foundries	Automotive
Steel Foundries (except Investment)	Automotive
Nonferrous Metal Die-Casting Foundries	Automotive
Aluminum Foundries (except Die-Casting)	Automotive
Other Nonferrous Metal Foundries (except Die-Casting)	Automotive
Custom Roll Forming	Automotive
Automobile Manufacturing	Automotive
Light Truck and Utility Vehicle Manufacturing	Automotive
Heavy Duty Truck Manufacturing	Automotive
Motor Vehicle Body Manufacturing	Automotive
Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	Automotive
Motor Vehicle Electrical and Electronic Equipment Manufacturing	Automotive
Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing	Automotive
Motor Vehicle Brake System Manufacturing	Automotive

Motor Vehicle Transmission and Power Train Parts Manufacturing	Automotive
Motor Vehicle Seating and Interior Trim Manufacturing	Automotive
Motor Vehicle Metal Stamping	Automotive
Other Motor Vehicle Parts Manufacturing	Automotive
Military Armored Vehicle, Tank, and Tank Component Manufacturing	Automotive
All Other Transportation Equipment Manufacturing	Automotive
Medicinal and Botanical Manufacturing	Biopharmaceuticals
Pharmaceutical Preparation Manufacturing	Biopharmaceuticals
In-Vitro Diagnostic Substance Manufacturing	Biopharmaceuticals
Biological Product (except Diagnostic) Manufacturing	Biopharmaceuticals
Taxi Service	Business Services
Limousine Service	Business Services
All Other Transit and Ground Passenger Transportation	Business Services
Data Processing, Hosting, and Related Services	Information Technology and Analytical Instruments
Passenger Car Leasing	Business Services
Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	Business Services
All Other Legal Services	Business Services
Payroll Services	Business Services
Architectural Services	Business Services
Landscape Architectural Services	Business Services
Engineering Services	Business Services
Drafting Services	Business Services

Custom Computer Programming Services	Information Technology and Analytical Instruments
Computer Systems Design Services	Information Technology and Analytical Instruments
Computer Facilities Management Services	Information Technology and Analytical Instruments
Other Computer Related Services	Information Technology and Analytical Instruments
Administrative Management and General Management Consulting Services	Business Services
Human Resources Consulting Services	Business Services
Process, Physical Distribution, and Logistics Consulting Services	Business Services
Other Management Consulting Services	Business Services
Other Scientific and Technical Consulting Services	Business Services
Translation and Interpretation Services	Business Services
All Other Professional, Scientific, and Technical Services	Business Services
Offices of Bank Holding Companies	Business Services
Offices of Other Holding Companies	Business Services
Corporate, Subsidiary, and Regional Managing Offices	Business Services
Facilities Support Services	Business Services
Employment Placement Agencies	Business Services
Executive Search Services	Business Services
Professional Employer Organizations	Business Services
Telephone Answering Services	Business Services
Telemarketing Bureaus and Other Contact Centers	Business Services
Convention and Trade Show Organizers	Business Services

Bituminous Coal and Lignite Surface Mining	Coal Mining
Bituminous Coal Underground Mining	Coal Mining
Anthracite Mining	Coal Mining
Support Activities for Coal Mining	Coal Mining
Telephone Apparatus Manufacturing	Communications Equipment and Services
Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	Communications Equipment and Services
Other Communications Equipment Manufacturing	Communications Equipment and Services
Primary Battery Manufacturing	Communications Equipment and Services
Cable and Other Subscription Programming	Communications Equipment and Services
Wireless Telecommunications Carriers (except Satellite)	Communications Equipment and Services
Satellite Telecommunications	Communications Equipment and Services
All Other Telecommunications	Communications Equipment and Services
Water Supply and Irrigation Systems	Construction Products and Services
Steam and Air-Conditioning Supply	Construction Products and Services
Industrial Building Construction	Construction Products and Services

Oil and Gas Pipeline and Related Structures Construction	Construction Products and Services
Power and Communication Line and Related Structures Construction	Construction Products and Services
Other Heavy and Civil Engineering Construction	Construction Products and Services
Asphalt Paving Mixture and Block Manufacturing	Construction Products and Services
Asphalt Shingle and Coating Materials Manufacturing	Construction Products and Services
Cement Manufacturing	Construction Products and Services
Concrete Block and Brick Manufacturing	Construction Products and Services
Concrete Pipe Manufacturing	Construction Products and Services
Lime Manufacturing	Construction Products and Services
Gypsum Product Manufacturing	Construction Products and Services
Cut Stone and Stone Product Manufacturing	Construction Products and Services
Mineral Wool Manufacturing	Construction Products and Services
All Other Miscellaneous Nonmetallic Mineral Product Manufacturing	Construction Products and Services
Power Boiler and Heat Exchanger Manufacturing	Construction Products and Services

Metal Tank (Heavy Gauge) Manufacturing	Construction Products and Services
Plumbing Fixture Fitting and Trim Manufacturing	Construction Products and Services
Fabricated Pipe and Pipe Fitting Manufacturing	Construction Products and Services
Furniture Merchant Wholesalers	Distribution and Electronic Commerce
Home Furnishing Merchant Wholesalers	Distribution and Electronic Commerce
Photographic Equipment and Supplies Merchant Wholesalers	Distribution and Electronic Commerce
Office Equipment Merchant Wholesalers	Distribution and Electronic Commerce
Computer and Computer Peripheral Equipment and Software Merchant Wholesalers	Distribution and Electronic Commerce
Other Commercial Equipment Merchant Wholesalers	Distribution and Electronic Commerce
Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers	Distribution and Electronic Commerce
Ophthalmic Goods Merchant Wholesalers	Distribution and Electronic Commerce
Other Professional Equipment and Supplies Merchant Wholesalers	Distribution and Electronic Commerce
Metal Service Centers and Other Metal Merchant Wholesalers	Distribution and Electronic Commerce
Coal and Other Mineral and Ore Merchant Wholesalers	Distribution and Electronic Commerce

Electrical Apparatus and Equipment, Wiring Supplies, and Related Equipment Merchant Wholesalers	Distribution and Electronic Commerce
Household Appliances, Electric Housewares, and Consumer Electronics Merchant Wholesalers	Distribution and Electronic Commerce
Other Electronic Parts and Equipment Merchant Wholesalers	Distribution and Electronic Commerce
Construction and Mining (except Oil Well) Machinery and Equipment Merchant Wholesalers	Distribution and Electronic Commerce
Farm and Garden Machinery and Equipment Merchant Wholesalers	Distribution and Electronic Commerce
Industrial Machinery and Equipment Merchant Wholesalers	Distribution and Electronic Commerce
Industrial Supplies Merchant Wholesalers	Distribution and Electronic Commerce
Service Establishment Equipment and Supplies Merchant Wholesalers	Distribution and Electronic Commerce
Transportation Equipment and Supplies (except Motor Vehicle) Merchant Wholesalers	Distribution and Electronic Commerce
Sporting and Recreational Goods and Supplies Merchant Wholesalers	Distribution and Electronic Commerce
Toy and Hobby Goods and Supplies Merchant Wholesalers	Distribution and Electronic Commerce
Jewelry, Watch, Precious Stone, and Precious Metal Merchant Wholesalers	Distribution and Electronic Commerce
Printing and Writing Paper Merchant Wholesalers	Distribution and Electronic Commerce
Stationery and Office Supplies Merchant Wholesalers	Distribution and Electronic Commerce

Industrial and Personal Service Paper Merchant Wholesalers	Distribution and Electronic Commerce
Drugs and Druggists' Sundries Merchant Wholesalers	Distribution and Electronic Commerce
Piece Goods, Notions, and Other Dry Goods Merchant Wholesalers	Distribution and Electronic Commerce
Men's and Boys' Clothing and Furnishings Merchant Wholesalers	Distribution and Electronic Commerce
Women's, Children's, and Infants' Clothing and Accessories Merchant Wholesalers	Distribution and Electronic Commerce
Footwear Merchant Wholesalers	Distribution and Electronic Commerce
Poultry and Poultry Product Merchant Wholesalers	Distribution and Electronic Commerce
Fish and Seafood Merchant Wholesalers	Distribution and Electronic Commerce
Meat and Meat Product Merchant Wholesalers	Distribution and Electronic Commerce
Fresh Fruit and Vegetable Merchant Wholesalers	Distribution and Electronic Commerce
Other Farm Product Raw Material Merchant Wholesalers	Distribution and Electronic Commerce
Plastics Materials and Basic Forms and Shapes Merchant Wholesalers	Distribution and Electronic Commerce
Other Chemical and Allied Products Merchant Wholesalers	Distribution and Electronic Commerce
Petroleum Bulk Stations and Terminals	Distribution and Electronic Commerce

Petroleum and Petroleum Products Merchant Wholesalers (except Bulk Stations and Terminals)	Distribution and Electronic Commerce
Wine and Distilled Alcoholic Beverage Merchant Wholesalers	Distribution and Electronic Commerce
Farm Supplies Merchant Wholesalers	Distribution and Electronic Commerce
Book, Periodical, and Newspaper Merchant Wholesalers	Distribution and Electronic Commerce
Flower, Nursery Stock, and Florists' Supplies Merchant Wholesalers	Distribution and Electronic Commerce
Tobacco and Tobacco Product Merchant Wholesalers	Distribution and Electronic Commerce
Paint, Varnish, and Supplies Merchant Wholesalers	Distribution and Electronic Commerce
Other Miscellaneous Nondurable Goods Merchant Wholesalers	Distribution and Electronic Commerce
Business to Business Electronic Markets	Distribution and Electronic Commerce
Wholesale Trade Agents and Brokers	Distribution and Electronic Commerce
Electronic Shopping and Mail-Order Houses	Distribution and Electronic Commerce
General Warehousing and Storage	Distribution and Electronic Commerce
Refrigerated Warehousing and Storage	Distribution and Electronic Commerce
Farm Product Warehousing and Storage	Distribution and Electronic Commerce

Other Warehousing and Storage	Distribution and Electronic Commerce
Commercial Air, Rail, and Water Transportation Equipment Rental and Leasing	Distribution and Electronic Commerce
Construction, Mining, and Forestry Machinery and Equipment Rental and Leasing	Distribution and Electronic Commerce
Office Machinery and Equipment Rental and Leasing	Distribution and Electronic Commerce
Other Commercial and Industrial Machinery and Equipment Rental and Leasing	Distribution and Electronic Commerce
All Other Business Support Services	Distribution and Electronic Commerce
Packaging and Labeling Services	Distribution and Electronic Commerce
Petroleum Lubricating Oil and Grease Manufacturing	Downstream Chemical Products
Synthetic Dye and Pigment Manufacturing	Downstream Chemical Products
Paint and Coating Manufacturing	Downstream Chemical Products
Adhesive Manufacturing	Downstream Chemical Products
Soap and Other Detergent Manufacturing	Downstream Chemical Products
Polish and Other Sanitation Good Manufacturing	Downstream Chemical Products
Surface Active Agent Manufacturing	Downstream Chemical Products
Toilet Preparation Manufacturing	Downstream Chemical Products
Explosives Manufacturing	Downstream Chemical Products
Custom Compounding of Purchased Resins	Downstream Chemical Products
Photographic Film, Paper, Plate, and Chemical Manufacturing	Downstream Chemical Products
All Other Miscellaneous Chemical Product and Preparation Manufacturing	Downstream Chemical Products

Metal Kitchen Cookware, Utensil, Cutlery, and Flatware (except Precious) Manufacturing	Downstream Metal Products
Saw Blade and Handtool Manufacturing	Downstream Metal Products
Prefabricated Metal Building and Component Manufacturing	Downstream Metal Products
Fabricated Structural Metal Manufacturing	Downstream Metal Products
Metal Window and Door Manufacturing	Downstream Metal Products
Sheet Metal Work Manufacturing	Downstream Metal Products
Ornamental and Architectural Metal Work Manufacturing	Downstream Metal Products
Metal Can Manufacturing	Downstream Metal Products
Other Metal Container Manufacturing	Downstream Metal Products
Hardware Manufacturing	Downstream Metal Products
Small Arms Ammunition Manufacturing	Downstream Metal Products
Ammunition (except Small Arms) Manufacturing	Downstream Metal Products
Small Arms, Ordnance, and Ordnance Accessories Manufacturing	Downstream Metal Products
All Other Miscellaneous Fabricated Metal Product Manufacturing	Downstream Metal Products
Research and Development in Nanotechnology	Education and Knowledge Creation
Research and Development in Biotechnology (except Nanobiotechnology)	Education and Knowledge Creation
Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)	Education and Knowledge Creation
Research and Development in the Social Sciences and Humanities	Education and Knowledge Creation
Junior Colleges	Education and Knowledge Creation

Colleges, Universities, and Professional Schools	Education and Knowledge Creation
Business and Secretarial Schools	Education and Knowledge Creation
Computer Training	Education and Knowledge Creation
Professional and Management Development Training	Education and Knowledge Creation
Flight Training	Education and Knowledge Creation
Apprenticeship Training	Education and Knowledge Creation
Language Schools	Education and Knowledge Creation
Exam Preparation and Tutoring	Education and Knowledge Creation
All Other Miscellaneous Schools and Instruction	Education and Knowledge Creation
Educational Support Services	Education and Knowledge Creation
Professional Organizations	Education and Knowledge Creation
Colleges, Universities, and Professional Schools (State Government)	Education and Knowledge Creation
All Other Schools and Educational Support Services (State Government)	Education and Knowledge Creation
Colleges, Universities, and Professional Schools (Local Government)	Education and Knowledge Creation

All Other Schools and Educational Support Services (Local Government)	Education and Knowledge Creation
Hydroelectric Power Generation	Electric Power Generation and Transmission
Fossil Fuel Electric Power Generation	Electric Power Generation and Transmission
Nuclear Electric Power Generation	Electric Power Generation and Transmission
Solar Electric Power Generation	Electric Power Generation and Transmission
Wind Electric Power Generation	Electric Power Generation and Transmission
Geothermal Electric Power Generation	Electric Power Generation and Transmission
Biomass Electric Power Generation	Electric Power Generation and Transmission
Other Electric Power Generation	Electric Power Generation and Transmission
Electric Bulk Power Transmission and Control	Electric Power Generation and Transmission
Hazardous Waste Collection	Environmental Services
Other Waste Collection	Environmental Services
Hazardous Waste Treatment and Disposal	Environmental Services
Solid Waste Combustors and Incinerators	Environmental Services
Other Nonhazardous Waste Treatment and Disposal	Environmental Services
Materials Recovery Facilities	Environmental Services
All Other Miscellaneous Waste Management Services	Environmental Services

US Postal Service	Federal Government Services
Federal Government, Civilian, Excluding Postal Service	Federal Government Services
Federal Government, Military	Federal Government Services
Monetary Authorities-Central Bank	Financial Services
Savings Institutions	Financial Services
Other Depository Credit Intermediation	Financial Services
Credit Card Issuing	Financial Services
Sales Financing	Financial Services
Consumer Lending	Financial Services
Real Estate Credit	Financial Services
International Trade Financing	Financial Services
Secondary Market Financing	Financial Services
All Other Nondepository Credit Intermediation	Financial Services
Mortgage and Nonmortgage Loan Brokers	Financial Services
Financial Transactions Processing, Reserve, and Clearinghouse Activities	Financial Services
Other Activities Related to Credit Intermediation	Financial Services
Investment Banking and Securities Dealing	Financial Services
Securities Brokerage	Financial Services
Commodity Contracts Dealing	Financial Services
Commodity Contracts Brokerage	Financial Services
Securities and Commodity Exchanges	Financial Services
Miscellaneous Intermediation	Financial Services
Portfolio Management	Financial Services
Investment Advice	Financial Services

Trust, Fiduciary, and Custody Activities	Financial Services
Miscellaneous Financial Investment Activities	Financial Services
Open-End Investment Funds	Financial Services
Other Financial Vehicles	Financial Services
Credit Bureaus	Financial Services
Finfish Fishing	Fishing and Fishing Products
Shellfish Fishing	Fishing and Fishing Products
Other Marine Fishing	Fishing and Fishing Products
Seafood Product Preparation and Packaging	Fishing and Fishing Products
Dog and Cat Food Manufacturing	Food Processing and Manufacturing
Other Animal Food Manufacturing	Food Processing and Manufacturing
Flour Milling	Food Processing and Manufacturing
Rice Milling	Food Processing and Manufacturing
Malt Manufacturing	Food Processing and Manufacturing
Wet Corn Milling	Food Processing and Manufacturing
Soybean and Other Oilseed Processing	Food Processing and Manufacturing
Fats and Oils Refining and Blending	Food Processing and Manufacturing
Breakfast Cereal Manufacturing	Food Processing and Manufacturing

Beet Sugar Manufacturing	Food Processing and Manufacturing
Cane Sugar Manufacturing	Food Processing and Manufacturing
Nonchocolate Confectionery Manufacturing	Food Processing and Manufacturing
Chocolate and Confectionery Manufacturing from Cacao Beans	Food Processing and Manufacturing
Confectionery Manufacturing from Purchased Chocolate	Food Processing and Manufacturing
Frozen Fruit, Juice, and Vegetable Manufacturing	Food Processing and Manufacturing
Frozen Specialty Food Manufacturing	Food Processing and Manufacturing
Fruit and Vegetable Canning	Food Processing and Manufacturing
Specialty Canning	Food Processing and Manufacturing
Dried and Dehydrated Food Manufacturing	Food Processing and Manufacturing
Fluid Milk Manufacturing	Food Processing and Manufacturing
Creamery Butter Manufacturing	Food Processing and Manufacturing
Cheese Manufacturing	Food Processing and Manufacturing
Dry, Condensed, and Evaporated Dairy Product Manufacturing	Food Processing and Manufacturing

Ice Cream and Frozen Dessert Manufacturing	Food Processing and Manufacturing
Frozen Cakes, Pies, and Other Pastries Manufacturing	Food Processing and Manufacturing
Cookie and Cracker Manufacturing	Food Processing and Manufacturing
Dry Pasta, Dough, and Flour Mixes Manufacturing from Purchased Flour	Food Processing and Manufacturing
Tortilla Manufacturing	Food Processing and Manufacturing
Roasted Nuts and Peanut Butter Manufacturing	Food Processing and Manufacturing
Other Snack Food Manufacturing	Food Processing and Manufacturing
Coffee and Tea Manufacturing	Food Processing and Manufacturing
Flavoring Syrup and Concentrate Manufacturing	Food Processing and Manufacturing
Mayonnaise, Dressing, and Other Prepared Sauce Manufacturing	Food Processing and Manufacturing
Spice and Extract Manufacturing	Food Processing and Manufacturing
Perishable Prepared Food Manufacturing	Food Processing and Manufacturing
All Other Miscellaneous Food Manufacturing	Food Processing and Manufacturing
Soft Drink Manufacturing	Food Processing and Manufacturing

Bottled Water Manufacturing	Food Processing and Manufacturing
Ice Manufacturing	Food Processing and Manufacturing
Breweries	Food Processing and Manufacturing
Wineries	Food Processing and Manufacturing
Distilleries	Food Processing and Manufacturing
Glass Container Manufacturing	Food Processing and Manufacturing
Grain and Field Bean Merchant Wholesalers	Food Processing and Manufacturing
Leather and Hide Tanning and Finishing	Footwear
Footwear Manufacturing	Footwear
Timber Tract Operations	Forestry
Forest Nurseries and Gathering of Forest Products	Forestry
Logging	Forestry
Support Activities for Forestry	Forestry
Manufactured Home (Mobile Home) Manufacturing	Furniture
Wood Kitchen Cabinet and Countertop Manufacturing	Furniture
Upholstered Household Furniture Manufacturing	Furniture
Nonupholstered Wood Household Furniture Manufacturing	Furniture
Metal Household Furniture Manufacturing	Furniture
Household Furniture (except Wood and Metal) Manufacturing	Furniture

Institutional Furniture Manufacturing	Furniture
Wood Office Furniture Manufacturing	Furniture
Office Furniture (except Wood) Manufacturing	Furniture
Showcase, Partition, Shelving, and Locker Manufacturing	Furniture
Mattress Manufacturing	Furniture
Hunting and Trapping	Hospitality and Tourism
Art Dealers	Hospitality and Tourism
Scenic and Sightseeing Transportation, Land	Hospitality and Tourism
Scenic and Sightseeing Transportation, Water	Hospitality and Tourism
Scenic and Sightseeing Transportation, Other	Hospitality and Tourism
Recreational Goods Rental	Hospitality and Tourism
Travel Agencies	Hospitality and Tourism
Tour Operators	Hospitality and Tourism
Convention and Visitors Bureaus	Hospitality and Tourism
All Other Travel Arrangement and Reservation Services	Hospitality and Tourism
Sports Teams and Clubs	Hospitality and Tourism
Racetracks	Hospitality and Tourism
Other Spectator Sports	Hospitality and Tourism
Museums	Hospitality and Tourism
Historical Sites	Hospitality and Tourism
Zoos and Botanical Gardens	Hospitality and Tourism
Nature Parks and Other Similar Institutions	Hospitality and Tourism
Amusement and Theme Parks	Hospitality and Tourism
Amusement Arcades	Hospitality and Tourism

Casinos (except Casino Hotels)	Hospitality and Tourism
Other Gambling Industries	Hospitality and Tourism
Skiing Facilities	Hospitality and Tourism
Marinas	Hospitality and Tourism
All Other Amusement and Recreation Industries	Hospitality and Tourism
Hotels (except Casino Hotels) and Motels	Hospitality and Tourism
Casino Hotels	Hospitality and Tourism
Bed-and-Breakfast Inns	Hospitality and Tourism
All Other Traveler Accommodation	Hospitality and Tourism
RV (Recreational Vehicle) Parks and Campgrounds	Hospitality and Tourism
Recreational and Vacation Camps (except Campgrounds)	Hospitality and Tourism
Rooming and Boarding Houses, Dormitories, and Workers' Camps	Hospitality and Tourism
Semiconductor Machinery Manufacturing	Information Technology and Analytical Instruments
Photographic and Photocopying Equipment Manufacturing	Information Technology and Analytical Instruments
Electronic Computer Manufacturing	Information Technology and Analytical Instruments
Computer Storage Device Manufacturing	Information Technology and Analytical Instruments
Computer Terminal and Other Computer Peripheral Equipment Manufacturing	Information Technology and Analytical Instruments
Audio and Video Equipment Manufacturing	Information Technology and Analytical Instruments
Bare Printed Circuit Board Manufacturing	Information Technology and Analytical Instruments

Semiconductor and Related Device Manufacturing	Information Technology and Analytical Instruments
Capacitor, Resistor, Coil, Transformer, and Other Inductor Manufacturing	Information Technology and Analytical Instruments
Electronic Connector Manufacturing	Information Technology and Analytical Instruments
Printed Circuit Assembly (Electronic Assembly) Manufacturing	Information Technology and Analytical Instruments
Other Electronic Component Manufacturing	Information Technology and Analytical Instruments
Electromedical and Electrotherapeutic Apparatus Manufacturing	Information Technology and Analytical Instruments
Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use	Information Technology and Analytical Instruments
Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	Information Technology and Analytical Instruments
Totalizing Fluid Meter and Counting Device Manufacturing	Information Technology and Analytical Instruments
Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	Information Technology and Analytical Instruments
Analytical Laboratory Instrument Manufacturing	Information Technology and Analytical Instruments
Irradiation Apparatus Manufacturing	Information Technology and Analytical Instruments
Other Measuring and Controlling Device Manufacturing	Information Technology and Analytical Instruments
Blank Magnetic and Optical Recording Media Manufacturing	Information Technology and Analytical Instruments

Software and Other Prerecorded Compact Disc, Tape, and Record Reproducing	Information Technology and Analytical Instruments
Software Publishers	Information Technology and Analytical Instruments
Direct Life Insurance Carriers	Insurance Services
Direct Health and Medical Insurance Carriers	Insurance Services
Direct Property and Casualty Insurance Carriers	Insurance Services
Direct Title Insurance Carriers	Insurance Services
Other Direct Insurance (except Life, Health, and Medical) Carriers	Insurance Services
Reinsurance Carriers	Insurance Services
Claims Adjusting	Insurance Services
All Other Insurance Related Activities	Insurance Services
Pension Funds	Insurance Services
Health and Welfare Funds	Insurance Services
Other Insurance Funds	Insurance Services
Trusts, Estates, and Agency Accounts	Insurance Services
Jewelry and Silverware Manufacturing	Jewelry and Precious Metals
Textile Bag and Canvas Mills	Leather and Related Products
Women's Handbag and Purse Manufacturing	Leather and Related Products
All Other Leather Good and Allied Product Manufacturing	Leather and Related Products
Electric Lamp Bulb and Part Manufacturing	Lighting and Electrical Equipment
Residential Electric Lighting Fixture Manufacturing	Lighting and Electrical Equipment

Commercial, Industrial, and Institutional Electric Lighting Fixture Manufacturing	Lighting and Electrical Equipment
Other Lighting Equipment Manufacturing	Lighting and Electrical Equipment
Power, Distribution, and Specialty Transformer Manufacturing	Lighting and Electrical Equipment
Motor and Generator Manufacturing	Lighting and Electrical Equipment
Switchgear and Switchboard Apparatus Manufacturing	Lighting and Electrical Equipment
Relay and Industrial Control Manufacturing	Lighting and Electrical Equipment
Storage Battery Manufacturing	Lighting and Electrical Equipment
Fiber Optic Cable Manufacturing	Lighting and Electrical Equipment
Other Communication and Energy Wire Manufacturing	Lighting and Electrical Equipment
Current-Carrying Wiring Device Manufacturing	Lighting and Electrical Equipment
Noncurrent-Carrying Wiring Device Manufacturing	Lighting and Electrical Equipment
Carbon and Graphite Product Manufacturing	Lighting and Electrical Equipment
All Other Miscellaneous Electrical Equipment and Component Manufacturing	Lighting and Electrical Equipment
Animal (except Poultry) Slaughtering	Livestock Processing
Meat Processed from Carcasses	Livestock Processing

Rendering and Meat Byproduct Processing	Livestock Processing
Poultry Processing	Livestock Processing
Livestock Merchant Wholesalers	Livestock Processing
Periodical Publishers	Marketing, Design, and Publishing
Book Publishers	Marketing, Design, and Publishing
Directory and Mailing List Publishers	Marketing, Design, and Publishing
All Other Publishers	Marketing, Design, and Publishing
News Syndicates	Marketing, Design, and Publishing
Libraries and Archives	Marketing, Design, and Publishing
Internet Publishing and Broadcasting and Web Search Portals	Marketing, Design, and Publishing
All Other Information Services	Marketing, Design, and Publishing
Interior Design Services	Marketing, Design, and Publishing
Industrial Design Services	Marketing, Design, and Publishing
Graphic Design Services	Marketing, Design, and Publishing
Other Specialized Design Services	Marketing, Design, and Publishing

Marketing Consulting Services	Marketing, Design, and Publishing
Advertising Agencies	Marketing, Design, and Publishing
Public Relations Agencies	Marketing, Design, and Publishing
Media Buying Agencies	Marketing, Design, and Publishing
Media Representatives	Marketing, Design, and Publishing
Outdoor Advertising	Marketing, Design, and Publishing
Direct Mail Advertising	Marketing, Design, and Publishing
Advertising Material Distribution Services	Marketing, Design, and Publishing
Other Services Related to Advertising	Marketing, Design, and Publishing
Marketing Research and Public Opinion Polling	Marketing, Design, and Publishing
Optical Instrument and Lens Manufacturing	Medical Devices
Surgical and Medical Instrument Manufacturing	Medical Devices
Surgical Appliance and Supplies Manufacturing	Medical Devices
Dental Equipment and Supplies Manufacturing	Medical Devices
Ophthalmic Goods Manufacturing	Medical Devices
Iron Ore Mining	Metal Mining
Gold Ore Mining	Metal Mining

Silver Ore Mining	Metal Mining
Copper, Nickel, Lead, and Zinc Mining	Metal Mining
Uranium-Radium-Vanadium Ore Mining	Metal Mining
All Other Metal Ore Mining	Metal Mining
Support Activities for Metal Mining	Metal Mining
Abrasive Product Manufacturing	Metalworking Technology
Plate Work Manufacturing	Metalworking Technology
Precision Turned Product Manufacturing	Metalworking Technology
Bolt, Nut, Screw, Rivet, and Washer Manufacturing	Metalworking Technology
Metal Heat Treating	Metalworking Technology
Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers	Metalworking Technology
Electroplating, Plating, Polishing, Anodizing, and Coloring	Metalworking Technology
Industrial Mold Manufacturing	Metalworking Technology
Special Die and Tool, Die Set, Jig, and Fixture Manufacturing	Metalworking Technology
Cutting Tool and Machine Tool Accessory Manufacturing	Metalworking Technology
Machine Tool Manufacturing	Metalworking Technology
Rolling Mill and Other Metalworking Machinery Manufacturing	Metalworking Technology
Power-Driven Handtool Manufacturing	Metalworking Technology
Welding and Soldering Equipment Manufacturing	Metalworking Technology
Music Publishers	Music and Sound Recording
Sound Recording Studios	Music and Sound Recording
Record Production and Distribution	Music and Sound Recording
Other Sound Recording Industries	Music and Sound Recording

Dimension Stone Mining and Quarrying	Nonmetal Mining
Crushed and Broken Limestone Mining and Quarrying	Nonmetal Mining
Crushed and Broken Granite Mining and Quarrying	Nonmetal Mining
Other Crushed and Broken Stone Mining and Quarrying	Nonmetal Mining
Construction Sand and Gravel Mining	Nonmetal Mining
Industrial Sand Mining	Nonmetal Mining
Kaolin and Ball Clay Mining	Nonmetal Mining
Clay and Ceramic and Refractory Minerals Mining	Nonmetal Mining
Potash, Soda, and Borate Mineral Mining	Nonmetal Mining
Phosphate Rock Mining	Nonmetal Mining
Other Chemical and Fertilizer Mineral Mining	Nonmetal Mining
All Other Nonmetallic Mineral Mining	Nonmetal Mining
Support Activities for Nonmetallic Minerals (except Fuels) Mining	Nonmetal Mining
Crude Petroleum Extraction	Oil and Gas Production and Transportation
Natural Gas Extraction	Oil and Gas Production and Transportation
Drilling Oil and Gas Wells	Oil and Gas Production and Transportation
Support Activities for Oil and Gas Operations	Oil and Gas Production and Transportation
Petroleum Refineries	Oil and Gas Production and Transportation
All Other Petroleum and Coal Products Manufacturing	Oil and Gas Production and Transportation

Oil and Gas Field Machinery and Equipment Manufacturing	Oil and Gas Production and Transportation
Pipeline Transportation of Crude Oil	Oil and Gas Production and Transportation
Pipeline Transportation of Natural Gas	Oil and Gas Production and Transportation
Pipeline Transportation of Refined Petroleum Products	Oil and Gas Production and Transportation
All Other Pipeline Transportation	Oil and Gas Production and Transportation
Geophysical Surveying and Mapping Services	Oil and Gas Production and Transportation
Pulp Mills	Paper and Packaging
Paper (except Newsprint) Mills	Paper and Packaging
Newsprint Mills	Paper and Packaging
Paperboard Mills	Paper and Packaging
Corrugated and Solid Fiber Box Manufacturing	Paper and Packaging
Folding Paperboard Box Manufacturing	Paper and Packaging
Other Paperboard Container Manufacturing	Paper and Packaging
Paper Bag and Coated and Treated Paper Manufacturing	Paper and Packaging
Stationery Product Manufacturing	Paper and Packaging
Sanitary Paper Product Manufacturing	Paper and Packaging
All Other Converted Paper Product Manufacturing	Paper and Packaging
Theater Companies and Dinner Theaters	Performing Arts
Dance Companies	Performing Arts
Musical Groups and Artists	Performing Arts

Other Performing Arts Companies	Performing Arts
Promoters of Performing Arts, Sports, and Similar Events with Facilities	Performing Arts
Promoters of Performing Arts, Sports, and Similar Events without Facilities	Performing Arts
Agents and Managers for Artists, Athletes, Entertainers, and Other Public Figures	Performing Arts
Independent Artists, Writers, and Performers	Performing Arts
Plastics Material and Resin Manufacturing	Plastics
Plastics Bag and Pouch Manufacturing	Plastics
Plastics Packaging Film and Sheet (including Laminated) Manufacturing	Plastics
Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing	Plastics
Unlaminated Plastics Profile Shape Manufacturing	Plastics
Plastics Pipe and Pipe Fitting Manufacturing	Plastics
Laminated Plastics Plate, Sheet (except Packaging), and Shape Manufacturing	Plastics
Polystyrene Foam Product Manufacturing	Plastics
Urethane and Other Foam Product (except Polystyrene) Manufacturing	Plastics
Plastics Bottle Manufacturing	Plastics
Plastics Plumbing Fixture Manufacturing	Plastics
All Other Plastics Product Manufacturing	Plastics
Broom, Brush, and Mop Manufacturing	Plastics
Commercial Printing (except Screen and Books)	Printing Services
Commercial Screen Printing	Printing Services
Books Printing	Printing Services
Support Activities for Printing	Printing Services
Printing Ink Manufacturing	Printing Services

Greeting Card Publishers	Printing Services
Industrial Valve Manufacturing	Production Technology and Heavy Machinery
Fluid Power Valve and Hose Fitting Manufacturing	Production Technology and Heavy Machinery
Other Metal Valve and Pipe Fitting Manufacturing	Production Technology and Heavy Machinery
Ball and Roller Bearing Manufacturing	Production Technology and Heavy Machinery
Farm Machinery and Equipment Manufacturing	Production Technology and Heavy Machinery
Lawn and Garden Tractor and Home Lawn and Garden Equipment Manufacturing	Production Technology and Heavy Machinery
Construction Machinery Manufacturing	Production Technology and Heavy Machinery
Mining Machinery and Equipment Manufacturing	Production Technology and Heavy Machinery
Food Product Machinery Manufacturing	Production Technology and Heavy Machinery
Sawmill, Woodworking, and Paper Machinery Manufacturing	Production Technology and Heavy Machinery
Printing Machinery and Equipment Manufacturing	Production Technology and Heavy Machinery
Other Industrial Machinery Manufacturing	Production Technology and Heavy Machinery
Other Commercial and Service Industry Machinery Manufacturing	Production Technology and Heavy Machinery

Industrial and Commercial Fan and Blower and Air Purification Equipment Manufacturing	Production Technology and Heavy Machinery
Heating Equipment (except Warm Air Furnaces) Manufacturing	Production Technology and Heavy Machinery
Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	Production Technology and Heavy Machinery
Turbine and Turbine Generator Set Units Manufacturing	Production Technology and Heavy Machinery
Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing	Production Technology and Heavy Machinery
Mechanical Power Transmission Equipment Manufacturing	Production Technology and Heavy Machinery
Other Engine Equipment Manufacturing	Production Technology and Heavy Machinery
Air and Gas Compressor Manufacturing	Production Technology and Heavy Machinery
Measuring, Dispensing, and Other Pumping Equipment Manufacturing	Production Technology and Heavy Machinery
Elevator and Moving Stairway Manufacturing	Production Technology and Heavy Machinery
Conveyor and Conveying Equipment Manufacturing	Production Technology and Heavy Machinery
Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	Production Technology and Heavy Machinery
Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing	Production Technology and Heavy Machinery
Packaging Machinery Manufacturing	Production Technology and Heavy Machinery

Industrial Process Furnace and Oven Manufacturing	Production Technology and Heavy Machinery
Fluid Power Cylinder and Actuator Manufacturing	Production Technology and Heavy Machinery
Fluid Power Pump and Motor Manufacturing	Production Technology and Heavy Machinery
Scale and Balance Manufacturing	Production Technology and Heavy Machinery
All Other Miscellaneous General Purpose Machinery Manufacturing	Production Technology and Heavy Machinery
Railroad Rolling Stock Manufacturing	Production Technology and Heavy Machinery
Gasket, Packing, and Sealing Device Manufacturing	Production Technology and Heavy Machinery
Small Electrical Appliance Manufacturing	Recreational and Small Electric Goods
Motorcycle, Bicycle, and Parts Manufacturing	Recreational and Small Electric Goods
Blind and Shade Manufacturing	Recreational and Small Electric Goods
Sporting and Athletic Goods Manufacturing	Recreational and Small Electric Goods
Doll, Toy, and Game Manufacturing	Recreational and Small Electric Goods
Office Supplies (except Paper) Manufacturing	Recreational and Small Electric Goods
Musical Instrument Manufacturing	Recreational and Small Electric Goods

Fastener, Button, Needle, and Pin Manufacturing	Recreational and Small Electric Goods
All Other Miscellaneous Manufacturing	Recreational and Small Electric Goods
State Government, Excluding Education and Hospitals	State Government Services
Fiber, Yarn, and Thread Mills	Textile Manufacturing
Broadwoven Fabric Mills	Textile Manufacturing
Narrow Fabric Mills and Schiffli Machine Embroidery	Textile Manufacturing
Nonwoven Fabric Mills	Textile Manufacturing
Knit Fabric Mills	Textile Manufacturing
Textile and Fabric Finishing Mills	Textile Manufacturing
Fabric Coating Mills	Textile Manufacturing
Carpet and Rug Mills	Textile Manufacturing
Curtain and Linen Mills	Textile Manufacturing
Rope, Cordage, Twine, Tire Cord, and Tire Fabric Mills	Textile Manufacturing
Hosiery and Sock Mills	Textile Manufacturing
Other Apparel Knitting Mills	Textile Manufacturing
Artificial and Synthetic Fibers and Filaments Manufacturing	Textile Manufacturing
Tobacco Manufacturing	Tobacco
Major Household Appliance Manufacturing	Trailers, Motor Homes, and Appliances
Truck Trailer Manufacturing	Trailers, Motor Homes, and Appliances
Motor Home Manufacturing	Trailers, Motor Homes, and Appliances

Travel Trailer and Camper Manufacturing	Trailers, Motor Homes, and Appliances
Burial Casket Manufacturing	Trailers, Motor Homes, and Appliances
Scheduled Passenger Air Transportation	Transportation and Logistics
Scheduled Freight Air Transportation	Transportation and Logistics
Nonscheduled Chartered Passenger Air Transportation	Transportation and Logistics
Nonscheduled Chartered Freight Air Transportation	Transportation and Logistics
Other Nonscheduled Air Transportation	Transportation and Logistics
Rail transportation	Transportation and Logistics
General Freight Trucking, Long-Distance, Truckload	Transportation and Logistics
General Freight Trucking, Long-Distance, Less Than Truckload	Transportation and Logistics
Specialized Freight (except Used Goods) Trucking, Long-Distance	Transportation and Logistics
Interurban and Rural Bus Transportation	Transportation and Logistics
Charter Bus Industry	Transportation and Logistics
Air Traffic Control	Transportation and Logistics
Other Airport Operations	Transportation and Logistics
Other Support Activities for Air Transportation	Transportation and Logistics
Support Activities for Rail Transportation	Transportation and Logistics
Other Support Activities for Road Transportation	Transportation and Logistics
Freight Transportation Arrangement	Transportation and Logistics
Packing and Crating	Transportation and Logistics
All Other Support Activities for Transportation	Transportation and Logistics
Postal Service	Transportation and Logistics

Petrochemical Manufacturing	Upstream Chemical Products
Industrial Gas Manufacturing	Upstream Chemical Products
Other Basic Inorganic Chemical Manufacturing	Upstream Chemical Products
Ethyl Alcohol Manufacturing	Upstream Chemical Products
Cyclic Crude, Intermediate, and Gum and Wood Chemical Manufacturing	Upstream Chemical Products
All Other Basic Organic Chemical Manufacturing	Upstream Chemical Products
Synthetic Rubber Manufacturing	Upstream Chemical Products
Phosphatic Fertilizer Manufacturing	Upstream Chemical Products
Pesticide and Other Agricultural Chemical Manufacturing	Upstream Chemical Products
Iron and Steel Mills and Ferroalloy Manufacturing	Upstream Metal Manufacturing
Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	Upstream Metal Manufacturing
Rolled Steel Shape Manufacturing	Upstream Metal Manufacturing
Steel Wire Drawing	Upstream Metal Manufacturing
Alumina Refining and Primary Aluminum Production	Upstream Metal Manufacturing
Secondary Smelting and Alloying of Aluminum	Upstream Metal Manufacturing
Aluminum Sheet, Plate, and Foil Manufacturing	Upstream Metal Manufacturing
Other Aluminum Rolling, Drawing, and Extruding	Upstream Metal Manufacturing
Nonferrous Metal (except Aluminum) Smelting and Refining	Upstream Metal Manufacturing
Copper Rolling, Drawing, Extruding, and Alloying	Upstream Metal Manufacturing
Nonferrous Metal (except Copper and Aluminum) Rolling, Drawing, and Extruding	Upstream Metal Manufacturing
Secondary Smelting, Refining, and Alloying of Nonferrous Metal (except Copper and Aluminum)	Upstream Metal Manufacturing
Iron and Steel Forging	Upstream Metal Manufacturing

Nonferrous Forging	Upstream Metal Manufacturing
Powder Metallurgy Part Manufacturing	Upstream Metal Manufacturing
Metal Crown, Closure, and Other Metal Stamping (except Automotive)	Upstream Metal Manufacturing
Spring Manufacturing	Upstream Metal Manufacturing
Other Fabricated Wire Product Manufacturing	Upstream Metal Manufacturing
Motion Picture and Video Production	Video Production and Distribution
Motion Picture and Video Distribution	Video Production and Distribution
Drive-In Motion Picture Theaters	Video Production and Distribution
Teleproduction and Other Postproduction Services	Video Production and Distribution
Other Motion Picture and Video Industries	Video Production and Distribution
Tire Manufacturing (except Retreading)	Vulcanized and Fired Materials
Tire Retreading	Vulcanized and Fired Materials
Rubber and Plastics Hoses and Belting Manufacturing	Vulcanized and Fired Materials
Rubber Product Manufacturing for Mechanical Use	Vulcanized and Fired Materials
All Other Rubber Product Manufacturing	Vulcanized and Fired Materials
Pottery, Ceramics, and Plumbing Fixture Manufacturing	Vulcanized and Fired Materials
Clay Building Material and Refractories Manufacturing	Vulcanized and Fired Materials
Flat Glass Manufacturing	Vulcanized and Fired Materials
Other Pressed and Blown Glass and Glassware Manufacturing	Vulcanized and Fired Materials
Glass Product Manufacturing Made of Purchased Glass	Vulcanized and Fired Materials

Ground or Treated Mineral and Earth Manufacturing	Vulcanized and Fired Materials
Ship Building and Repairing	Water Transportation
Boat Building	Water Transportation
Deep Sea Freight Transportation	Water Transportation
Deep Sea Passenger Transportation	Water Transportation
Coastal and Great Lakes Freight Transportation	Water Transportation
Coastal and Great Lakes Passenger Transportation	Water Transportation
Inland Water Freight Transportation	Water Transportation
Inland Water Passenger Transportation	Water Transportation
Port and Harbor Operations	Water Transportation
Marine Cargo Handling	Water Transportation
Navigational Services to Shipping	Water Transportation
Other Support Activities for Water Transportation	Water Transportation
Sawmills	Wood Products
Wood Preservation	Wood Products
Hardwood Veneer and Plywood Manufacturing	Wood Products
Softwood Veneer and Plywood Manufacturing	Wood Products
Engineered Wood Member (except Truss) Manufacturing	Wood Products
Truss Manufacturing	Wood Products
Reconstituted Wood Product Manufacturing	Wood Products
Wood Window and Door Manufacturing	Wood Products
Cut Stock, Resawing Lumber, and Planing	Wood Products
Other Millwork (including Flooring)	Wood Products
Wood Container and Pallet Manufacturing	Wood Products

Prefabricated Wood Building Manufacturing	Wood Products
All Other Miscellaneous Wood Product Manufacturing	Wood Products

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Appendix B – The Missouri Hyperloop Project's Benefits, Impacts, Opportunity Costs and Risks

The Missouri Hyperloop Project's Benefits and Impact

As detailed in Section 4, the Missouri Hyperloop presents significant benefits to both Missouri and the United States. It is more than project of national importance, it is a project of national strategic ingenuity, on par with the first interstate, the first railroad, the first pipeline and the first commercial airport.

Specifically, these are the public benefits and economic impact of Missouri Hyperloop:

- The new economic megaregion created by linking Kansas City, Columbia, and St. Louis via hyperloop would rank among the top 10 in the United States, significantly improving Missouri's global competitiveness for high quality jobs and talent.
- An estimated annual economic impact of $1.67 -- $3.68 billion.
- The creation of between 7,600 and 17,200 new jobs.
- Increased real estate values around portal locations.
- A significant strengthening of key industry clusters, including Automotive, Chemical Products, Business Services, Tech, Transportation and Logistics, and Aerospace.
- Increased tax revenues for state and local jurisdictions.
- A 50% reduction in accident fatalities and serious injuries along I-70.
- Up to 10 additional years of life expectancy for I-70 at current repair funding levels.
- A reduction of over 530,000 metric tons of CO_2 emissions.

The Missouri Hyperloop Project: Opportunity Cost

The opportunity cost of taking the well-traveled road of only traditional surface transportation are staggering and are potentially greater than the actual costs of this project.

The benefits and impact of the project must also be understood in that context. The infrastructure investments that have made Missouri (and the United States) safe, connected and prosperous so far cannot be sustained into the future.

With an annual GDP of over $315 billion, Missouri is one of the world's largest economies. Yet, the infrastructure underpinning this economy earned a grade of "C minus" from the American Society of Civil Engineers[72]. This disconnect is not sustainable. Without significant upgrades to our infrastructure, Missouri's economic growth will be severely constrained.

However, this is not about Missouri alone. This same story is true for all of our neighboring states and is just a microcosm of the crisis facing the United States[73].

The cost to Missouri of building or rebuilding our surface transportation systems to meet the basic safety rankings is projected as [$x], which is [x%] greater than building Missouri Hyperloop. In addition, even if this traditional approach were feasible, it would rely on available funds which are projected to tap out at [$x] over the next decade.

A public-private partnership to build the Missouri Hyperloop represents the state's best opportunity not only to upgrade its transportation network but to re-invest in its current system of riverports, roads, and runways. It also puts Missouri in the driver's seat for other transportation innovation such as dedicated highway lanes for autonomous vehicles and last-mile solutions within metropolitan areas.

The previous, great generations before us all faced the same opportunity costs. It is worth noting that the initial $60MM bond issue to catalyze construction of the US Interstate system in Missouri in the early 20th century would be the equivalent of over $750,000,000 today's dollars.

[72] https://www.infrastructurereportcard.org/state-item/missouri/
[73] https://www.infrastructurereportcard.org/state-item/ /

The Missouri Hyperloop Project: The Risks

Missouri Hyperloop presents significant risks to Missouri, the United States, and the private sector partners who are critical to its completion.

Specifically, these are the some of the key risks involved of Missouri Hyperloop:

1. Risk that the technology does not work as intended over a longer distance
2. Risk that the Hyperloop will never be commercially self-sustaining and thereby always requiring some level of Governmental subsidy
3. Risk that the Missouri Hyperloop is not the first in the nation and therefore not a central component of any future network of tubed transportation.
4. Risk that the technology cannot be certified for human safety by US regulators.
5. Risk that we cannot attract sufficient private capital to the project.
6. Risk that the private sector will not want to take the performance risk of the project because the technology has not been tested on a commercial scale.
7. Risk that other, as yet unforeseen modes of transportation render hyperloop technology commercially irrelevant.
8. Risk that the system cannot reach speeds sufficient to deliver the social and economic benefits it promises.

Appendix B -- Concept for the Missouri Hyperloop Corporation

Mission

Complete the Missouri Hyperloop Project, beginning with the completion of the Certification Track for International Tube Transport Center of Excellence.

> The sole mission of the Missouri Hyperloop Corporation is to ensure the completion, efficient operation and sustainability of The Missouri Hyperloop Project. This includes
>
> - developing the financing plan,
> - working with governments at all levels (federal, state and local) to access public sector funding and financing
> - procuring private sector partners and
> - overseeing the public interest in completing the "Missouri Hyperloop Project,"

Vision

One State, united to lead for the nation.
One Public Research University, leading a consortium of the nation's top public research universities dedicated to transformational transportation technologies.
One globally competitive region in the heartland as the central hub for a nationwide hyperloop system. The *First* Hyperloop System completed and operational in the United States.

The vision reflects the commitment and aspiration to complete the Missouri Hyperloop.

We envision the project as a self-sustaining solution that serves local travelers and transports freight through this vital transportation corridor as the first completed hyperloop in a nationwide system.

Missouri Hyperloop Corporation will be the "bridge" between federal, state, local authorities and the private sector technology and development partners. The Corporation will act as a catalyst for coordinated and cooperative action alongside these partners and will serve as a focal point for the constant emphasis of our unity of purpose, as we strive together to reach the goal defined in our Mission.

Values

Unity – Missouri Hyperloop unifies the state of Missouri in service to unifying our nation through transformational human and freight connectivity.

Prosperity – Missouri Hyperloop provides substantial improvement in the livability, economic health and workforce productivity throughout the state.

Leadership – Missouri Hyperloop leads the way for the nation, knowing we are exploring and opening a new frontier as we so often have for the nation.

Speed and Safety – Missouri Hyperloop will deliver extraordinary speed, never before possible in surface transportation, for people and freight. No matter how fast it is, it is ineffective without delivering extraordinary safety, never before possible in surface transportation.

Equity and Economy – Missouri Hyperloop propels Missouri economic development and creates completely new economic opportunities with true rural, racial and regional equity[i].

Our values are our guiding principles. The Corporation will use them to help guide decision-making in alignment with our Vision and our Mission. Each of them reflects a key priority that, in and of itself, is worthy of our focus in the pursuit of our Mission.

Because each Value is of such great importance, we recognize the possibility that situations may arise from time to time when we are faced with the necessity of choosing among them or giving one a higher priority than another. Nonetheless, we will continuously seek to improve these trade-offs as they present themselves, always working to achieve an optimal result that strikes the right balance among them. By following this approach, we will strive to deliver our project in the best way, the fastest way, and the right way

Appendix C - Potential Funding and Financing Sources

There currently are no federal funds authorized for hyperloop projects. However, as we focus on Phase I of The Missouri Hyperloop Project, the **Certification Track for International Tube Transport Center of Excellence:**

Recent legislation pending in this Congress contemplates some appropriation requests for the **US Department of Transportation's (USDOT) New and Emerging Transportation Technology (NETT) Council** and possible funds for tube transport from **Maglev grants**.

As Congress prepares to reauthorize the **Fixing America's Surface Transportation (FAST)** Act, which expires on September 30, 2020, it may provide funding for new and emerging technologies.

In the interim, Missouri DOT potentially could seek funding under the **Advanced Transportation and Congestion Management Technologies Deployment** program, which was authorized under the FAST Act for an additional $60 million annually. The program funds the deployment of advanced transportation and congestion management technologies.

The Better Utilizing Investments to Leverage Development, or **BUILD Transportation Discretionary Grant** program, provides a unique opportunity for the DOT to invest in road, rail, transit and port projects that promise to achieve national objectives. Previously known as Transportation Investment Generating Economic Recovery, or TIGER Discretionary Grants, Congress has dedicated nearly $7.1 billion for ten rounds of National Infrastructure Investments to fund projects that have a significant local or regional impact.

Since 2009, the Program has provided a combined $7.1 billion to 554 projects in all 50 states, the District of Columbia, Puerto Rico, Guam, the Virgin Islands: $1.5 billion for TIGER I, $600 million for TIGER II, $527 million for TIGER III, $500 million for TIGER IV, $474 million for TIGER V, $600 million for TIGER VI, $500 million for TIGER VII, $500 million for TIGER VIII, $500 million for TIGER IX, and $1.5 billion for BUILD FY 2018.

For projects located in urban areas, the minimum award is $5 million. Please note that the minimum total project cost for a project located in an urban area must be $6.25 million to meet match requirements. For projects located in rural areas, the minimum award is $1 million.

The maximum award for all projects is $25 million. Not more than $90 million can be awarded to a single State.

INFRA Grants were established in the 2015 Fixing America's Surface Transportation (FAST) Act and utilizes updated criteria for evaluating projects to align them with national and regional economic vitality goals. The program increases the impact of projects by leveraging federal grant funding and incentivizing project sponsors to pursue innovative strategies, including public-private partnerships.

Additionally, the new program promotes the incorporation of innovative technology that will improve our transportation system. INFRA will also hold recipients accountable for their performance in project delivery and operations. The program focuses on projects that generate national or regional economic, mobility, and safety benefits.

Technical evaluation teams made up of Departmental staff will determine whether projects satisfy statutory requirements and rate how well they address the selection criteria outlined in the NOFO. The Senior Review Team, comprised of Departmental leadership, will then consider the applications and the technical evaluations to determine which projects to advance to the Secretary for consideration. The Secretary will ultimately make the final selection for awards, consistent with the statutory requirements for INFRA Grants and the selection criteria in the NOFO.

To be eligible for an INFRA grant, a project must be:

- a highway freight project carried out on the National Highway Freight Network (23 U.S.C. 167)

- a highway or bridge project carried out on the National Highway System (NHS) including projects that add capacity on the Interstate System to improve mobility or projects in a national scenic area
- a railway-highway grade crossing or grade separation project; or
- a freight project that is:
    - an intermodal or rail project, or
    - within the boundaries of a public or private freight rail, water (including ports), or intermodal facility, is a surface transportation infrastructure project necessary to facilitate direct intermodal interchange, transfer, or access into or out of the facility, and will significantly improve freight movement on the National Highway Freight Network. For these projects Federal funds can only support project elements that provide public benefits.

The minimum award for a large project is $25 million.[ii]

The capital gains tax benefits conferred on investors in **Opportunity Zones** could be an attractive "sweetener" to potential private-sector partners. Specifically, it may be possible to separate any real estate investments from the overall operation of the track, which would allow investors to mitigate or even eliminate downstream tax consequences should the real estate associated with the project increase in value.

A minimum of $50-$100 million for research and development of a TTS project needs to be available within the next 3 years, MO DOT alone, or in collaboration with a private partner, also may be able to secure low cost financing under the **Transportation Infrastructure Finance and Innovation Act (TIFIA)** or the private partner may be able to secure low cost financing though **Private Activity Bond (PAB)** authorization. The project may not be eligible for financing until it is commercially viable or possibly, if the certification track generates revenues from fees.[74]

Transportation Infrastructure Finance and Innovation Act (TIFIA)

[74] https://www.transportation.gov/buildamerica/programs-services/tifia/program-guide.

Surface transportation projects are eligible for loans and loan guarantees. USDOT or Congress would need to confirm eligibility. The Loan principal is generally limited to 33 percent of eligible project costs (the law allows loans up to 49 percent of eligible project costs, but this is rarely done). The interest rate is the U.S. treasury rate for a comparable term. The maximum term of a TIFIA loan is 35 years from substantial completion or the useful life of asset (whichever is less). The borrower may defer principal and interest payments for up to 5 years from substantial completion. The borrower may draw down standby lines of credit during the first 10 years of project operations and are available up to 10 years after substantial completion of the project. TIFIA credit instruments are repayable, in whole or in part from dedicated revenue sources that also secure the senior project obligations. (The project must have a dedicated revenue source pledged to secure both the TIFIA and senior debt financing). USDOT accepts applications on a rolling basis. DOT charges a fee to pay for the cost of legal and financial consultants and has a stringent process for screening creditworthiness.

Private Activity Bonds (PABs)

Private entities financing Highway and freight transfer facilities can issue tax-exempt bonds through a government conduit issuer with approval from DOT.

The applicant must submit a written application to DOT that includes: (1) amount of allocation requested; (2) proposed date of bond issuance; (3) date of inducement by the bond issuer; (4) draft bond counsel opinion letter; (5) financing/development team information; (6) borrower information; (7) project description; (8) project schedule; (9) financial structure; (10) description of title 23 or 49 funding received by the project; and (11) information regarding project readiness. Applicants must list major permits and approvals necessary for construction of the project and the date, or projected date, of the receipt of such permits or approvals. DOT evaluates applications based on applicable statutory criteria and the availability of tax-exempt authority for the type and location of the project for which the allocation is requested. The issuer must expend at least 95 percent of the net proceeds of bond issues for qualified highways or surface freight transfer facilities within 5 years from the date of issue or must use all unspent proceeds to redeem bonds of the issue within 90 days after the conclusion of the five-year period.

The issuer may request an extension if it can establish that the failure to expend the funds was due to circumstances beyond its control.

> Recent uses involving a state government conduit issuer of PABs has included the State of Florida with Virgin Trains (once called Brightline). In this 2018-2019 example, new routes estimated at $4 billion, going from Miami to Orlando, have proven viable and popular to finance with relatively modest improvement goals. It seems plausible that new cargo routes destined for airside to airside multimodal transfer facilities could attract substantial investment once regulatory approvals and system performance have been determined.

Port Authority Bonds

The power of Missouri Port Authorities is spelled out in Section 68.025 of the Missouri Revised Statutes (RSMo.). Notably, Section 68.025.1.15, RSMo., permits Port Authorities to construct commercial developments, mixed-use developments, terminals, warehouses, and more within their territorial jurisdiction. Additionally, Section 68.025.2, RSMo., grants them the ability to enter into agreements with private operators for the joint development of property. It appears that these two sections of current Missouri law would allow for both the St. Louis and Kansas City Port Authorities to not only lease the needed land for a Tube Transport International Center of Excellence, but to also enter into the needed development agreements with private operators.

Missouri Port Authorities are also granted the ability to issue revenue bonds and notes in Section 68.040.1, RSMo. A certification track is likely not bondable due to a lack of initial revenues, but commercial expansion would provide the future income needed for a bond issue. It is possible that the proceeds from these bonds could be used to help move the project from a certification phase to a commercial phase in Missouri.

Note on Private Capital

The Blue Ribbon Panel concludes that there is substantial private capital—via both debt and equity instruments—available for infrastructure projects. For example, many large contractors operating in the United States have set up development arms through which they provide equity to projects. In addition, there are a number of international infrastructure funds which also provide equity to greenfield construction projects. There are also a number of providers of private debt to infrastructure projects. Lenders include many of the European and Japanese banks. In addition, through the issuance of Private Activity Bonds, the US capital markets may also be accessed for the project.

Given the complexity of private infrastructure funding, it would be advisable for the Missouri Hyperloop Corporation to engage an investment banker with deep expertise in this field.

Appendix D: Blue Ribbon Panel Members

Jeff Aboussie

Jeff served as lobbyist for the St. Louis Building & Construction Trades Council 2009-2016. Prior to the Building Trades, he was a 35-year member of the International Union of Operating Engineers Local 513 and worked as a business representative as well as an International Representative of 6 ½ years. He has consulted on large infrastructure projects such as the I-64 Rebuild and as well as efforts to bring the NGA to the St. Louis region. Jeff is currently a member of the St. Louis County Building Commission and serves as Governmental Affairs Director for the International Union of Operating Engineers in Missouri. He previously served as President of Pride Labor/Management Committee and on the boards of the United Way, the Missouri AFL-CIO, and the City of St. Louis Diversity Board for inclusion and Workforce Development.

Cathy Bennett

Cathy K. Bennett is Senior Vice President for Public Policy for the Greater Kansas City Chamber of Commerce where she oversees the Chamber's advocacy and government relations work for the states of Missouri and Kansas as well as policy work at the local and federal levels. A 16-year veteran with the KC Chamber, Cathy and her team direct the Chamber's "Big 5 Transportation Initiative" focused on advancing transportation

innovation in the KC metro area and improving transit access to jobs in the bi-state region. The KC Chamber has been an active advocate for innovative funding solutions to the state's transportation needs and recently completed a partnership with Google Fiber to measure regional mobility in the Kansas City bi-state region. Cathy also oversees the KC Chamber's workforce development and diversity and inclusion initiatives.

Tom Blair

Tom is the District Engineer for St. Louis for the Missouri Department of transportation. As the head of MODOT's "Road to Tomorrow" initiative studying ways to spur innovation along the I-70 corridor, Tom led a group of engineers in drafting Missouri's original proposal to build a Hyperloop connecting Kansas City, Columbia, and St. Louis.

Travis Brown

Travis Brown serves as President of Heartland Hyperloop, Inc., whose mission is to make Missouri the pioneer for hyperloop development and implementation. He also serves as President for Grow Missouri Inc., which is responsible for various public outreach efforts in Missouri, including FLY314. Additionally, he is the Chief Executive Officer of First Rule, a Saint Louis based government and public affairs network.

Travis is an instrument-rated private pilot with over 4,600 hours of total flight time across North America and is a member of the Elliott Society in Washington University's Olin School of Business. He also serves on the Chesterfield, MO-based Board of Directors for the International

Humanitarian Organization Wings of Hope, which manages a fleet of nearly 70 aircraft with deployments worldwide.

Prior Saint Louis corporate transaction experience includes five years with the Monsanto Company as a manager of State and Local Government Affairs responsible for the Midwest Region. In this capacity, Travis worked with Creve Coeur headquarters and Chesterfield Village site selection expansions and the passage of the first small business incubator authorization act for the Nidus Center for Scientific Enterprise (1997). He holds a Master in Business Administration with an emphasis in private equity/entrepreneurship from Washington University in Saint Louis, and two undergraduate degrees from the University of Missouri-Columbia.

Mun Choi

Mun Y. Choi was named the 24th president in the history of the University of Missouri System in November 2016, and began in March 2017. As president, Dr. Choi serves as the chief executive and academic officer of the UM System, a land-grant institution that provides centralized administration for four universities, a health care system, and extension program, and ten research and technology parks. Dr. Choi oversees all academic, public, business, financial and related affairs of the UM System under the policies and general supervision of the University of Missouri Board of Curators.

As a product of and passionate champion for public higher education, Dr. Choi advocates tirelessly on behalf of the four universities of the UM System with state and national business, political and civic leaders to achieve excellence. In partnership with the board and university leadership, Dr. Choi introduced a new collective vision for the UM System in September 2018: to advance the opportunities for success and well-being in Missouri, the nation and the world through transformative teaching, research, innovation, engagement and inclusion.

To fulfill this vision, Dr. Choi also announced the Missouri Compacts for Achieving Excellence in September 2018. The Missouri Compacts are a promise to achieve excellence through student success; research and creative works; engagement and outreach; inclusive excellence; and planning, operations and stewardship to best serve our students and Missourians. Supported by one-time investments of up to $260 million from the UM System, the Missouri Compacts support the universities' five-year strategic plans.

Tom Dempsey

Tom Dempsey brings extensive experience in issue advocacy, legislative initiatives, and public policy issues. Dempsey was first elected to the Missouri State Senate in 2007, where he quickly rose to the rank of Majority Floor Leader before being unanimously elected by his colleagues to serve as the Senate President Pro-Tem in 2013. He previously served seven years in the Missouri House of Representatives (2001-2007), where he also held key leadership posts as Majority Leader and Chairman of the Job Creation and Economic Development Committee.

Throughout his career, Dempsey has been known for his pragmatic, common sense leadership and getting results . He is the only person to have served as the Majority Leader in both the Missouri Senate and House of Representatives. During his tenure as Senate President Pro Tempore, the General Assembly adopted the first tax cut in 100 years, addressed the insolvency of the Worker's Compensation Second Injury Fund, supported a major bonding bill to invest in higher education and workforce development, and handled the largest rewrite of the criminal code in 30 years. The Legislature also passed an initiative to increase transportation funding, two significant education reform bills to spur student achievement, and a successful special session to attract a major economic development opportunity for the Aerospace Industry in St. Louis.

Rob Dixon

Rob Dixon is the Director of the Missouri Department of Economic Development.

Before becoming director, Rob served as the President/CEO of the Missouri Community College Association. MCCA is a membership organization for Missouri's community colleges, providing government advocacy, networking, and education resources for its members. It is the largest higher education association in the state, with approximately 2,000 members.

Rob also served in a variety of roles at the Springfield Area Chamber of Commerce. His overall responsibilities included leadership and management of staff and programs in economic and workforce development, public affairs, local government policy, communications, community development, and strategic planning. Rob Dixon also served as the Executive Director of the Hollister Area of Chamber of Commerce.

Rob joined the U.S. Marine Corps after high school, where he served as an intelligence analyst in Afghanistan and Pakistan immediately after the 9/11 terrorist attacks. He was recognized for leadership and performance as a U.S. Marine. Rob received an honorable discharge as a sergeant after five years in the Marine Corps.

Rob has a Master of Public Administration degree from Missouri State University, a Bachelor of Arts in Political Science from the University of Missouri – St. Louis, and an Associate of Arts in Political Science from St. Charles Community College.

Warren Erdman

Warren K. Erdman is executive vice president administration and corporate affairs for Kansas City Southern (KCS). In this role, he is responsible for administration and external affairs. His administrative responsibilities include the KCS legal department, claims, real estate and industrial development, facilities management, environmental and railroad security functions in the U.S. His external affairs responsibilities include state, local and federal regulatory affairs, government relations and communications. He participates in KCS' long-term project development and planning to meet the long-term infrastructure needs of the railroad and the communities it serves.

Prior to joining KCS in 1997, Erdman served as chief of staff to U.S. Senator Christopher S. Bond of Missouri. In that capacity, he was the chief staff person in charge of the Senator's operations in his Washington office and six local offices in Missouri. He served former Missouri Governor John Ashcroft in the Governor's office in 1985 and former Missouri Governor Bond in the Governor's office between 1981 and 1984.

Erdman is involved in numerous civic organizations in Kansas City, and public affairs in Missouri and at the federal level. He is a former chairman of The University of Missouri Board of Curators which is the governing body of the University of Missouri System and served as a member of that board from 2005 until 2012. He is a member of the University of Missouri-Kansas City Trustees and served as its real estate committee chairman, and the UMKC Foundation and chairs its Compensation Committee. He is also a member of the Westminster College, Fulton, Missouri Board of Trustees, its executive committee and a graduate of the College.

Travis Fitzwater

Rep. Travis Fitzwater, a Republican, represents parts of Callaway and Cole Counties (District 49) in the Missouri House of Representatives. He was elected to his first two-year term in November 2014.

In addition to his legislative duties, Rep. Fitzwater has worked in non-profit management as a marketing coordinator and chief operating officer. He's also started a business, Fitzwater Enterprises, LLC, and worked on staff with a campus ministry teaching students about leadership and faith principles.

Rep. Fitzwater is a board member at the Jefferson City Church of the Nazarene and Chairman of Jefferson City Young Life. He is a member of the Fulton Area Chamber of Commerce, National Rifle Association, Americans for Prosperity, Missouri Society of Association Executives, Missouri Governor's Student Leadership Forum, Callaway County Young Professionals and Jefferson City Young Republicans. He also is a former member of the Holts Summit Fire Protection District Board.

Rep. Fitzwater earned his bachelor's degree in Political Science, with a focus on International Relations, from Presbyterian College in Clinton, SC.

Rep. Fitzwater was born in Cleveland, OH. He currently resides in Holts Summit with his wife Amy. They have two daughters, Sadie & Eliza.

Derek Grier

Rep. Derek Grier, a Republican, represents St. Louis County (parts of Chesterfield, Ballwin, Winchester, and Town and Country). He was elected to his first two-year term in November 2016.

In addition to his legislative responsibilities, Rep. Grier owns and operates a small business in the St. Louis region focused on real estate management, acquisitions, and consulting. He has been an active member of numerous business organizations, including the Chamber of Commerce, Progress 64 West, and the Urban Land Institute. Rep. Grier holds a Broker's license with the Missouri Real Estate Commission, is a member of the St. Louis Realtors Association, and has a B.A. in business administration from Principia College.

Rep. Grier has lived in and around the 100th District for most of his life and currently resides in the district with his wife, Ashley. He is the proud father of two boys, Jack and Logan.

Chris Gutierrez

Chris is the President of KC SmartPort, Inc., a KCADC affiliate organization focused on attracting freight based economic development to the greater Kansas City region and providing thought leadership to the supply chain industry in Kansas City. Chris has been active in economic development and logistics for over 25 years. He joined KC SmartPort in 2003.

Rhonda Hamm-Niebruegge

Rhonda Hamm-Niebruegge has been the Director of St. Louis Lambert International Airport (STL) since January 2010 as appointed by St. Louis City Mayor Francis Slay.

The Airport is the primary air carrier facility for the St. Louis region that serves more than 14.7 million passengers annually. Ms. Hamm-Niebruegge manages 500 employees with revenues averaging 165 million dollars annually. She is also Chairwoman of the 17-member St. Louis Airport Commission.

Prior to STL, Ms. Hamm-Niebruegge logged over 25 years in aviation management positions with American Airlines, Trans World Airlines (TWA) and Ozark Air Lines; a majority of her career has been based in St. Louis, Missouri. Ms. Hamm-Niebruegge retired in 2009 as the Managing Director of American Airlines' St. Louis operation, a position she held beginning in 2002. Before the American and TWA merger, she held the position of Vice President of TWA's North American Operations, responsible for an $800 million budget encompassing 100 airports and 8,000 TWA employees.

Ms. Hamm-Niebruegge currently serves on the National Freight Advisory Committee, an advisory board serving the U.S. Department of Transportation. She serves on the oversight committee of the Airport Cooperative Research Program. She also serves as a board member for the St. Louis Regional Chamber, Christian Hospital (BJC HealthCare), the International Women's Forum, Ranken Technical College Board and the St. Louis Civic Pride Foundation. She's the former Chairperson of the Advisory Board of John Cook School of Business at Saint Louis University; past President of the Board Habitat for Humanity Saint Louis.

Mike Kehoe

Lieutenant Governor Kehoe was appointed to this position on 18 June, 2018.

Prior to serving as lieutenant governor, Senator Kehoe represented the Sixth Senatorial District covering seven, mid-Missouri counties: Cole, Gasconade, Maries, Miller, Moniteau, Morgan and Osage. First elected in 2010 and re-elected in 2014 Kehoe served as the Assistant Majority Floor Leader for two years and the Majority Floor leader for three years. In this leadership role, he served as Chairman of the Senate Rules, Joint Rules, Resolutions and Ethics Committee and Vice-Chairman of the Senate Gubernatorial Appointments Committee, and was also a member of the Administration and Agriculture Committees. Senator Kehoe previously served as the chair of both the Commerce and Transportation committees, as well as a member of the Appropriations and Education committees.

As senator, Kehoe has been honored by the Missouri Cattlemen's Association, the Missouri Association of Electric Cooperatives, and most recently, as the 2016 Missouri Community College Association Distinguished Legislator Award recipient. As a businessman, he has won numerous awards – including the Time Magazine Quality Dealer Award, Ford's President Award, and induction into the Automotive Hall of Fame, just to name a few. Community

service is part of the Kehoe tradition as well – serving as chairman of the Jefferson City Chamber of Commerce, two-time United Way Fund Drive Chairman, and he remains a strong supporter of numerous youth development activities from Boy Scouts to 4-H.

Mike Lally

Michael Lally is a vice-president and shareholder with Olsson Associates, a 1100 plus person full service engineering consulting firm. At Olsson, he leads business development efforts across the firm's fastest growing region which includes the states of Missouri, Kansas, Iowa, and Arkansas. He also has client management, project executive, and special project responsibilities. He holds a B.S. and M.S. in Geological Engineering from Missouri University of Science & Technology (formerly University of Missouri-Rolla) and a Master of Business Administration degree with an emphasis in finance from the University of Missouri-Kansas City. He is a professional engineer and professional geologist and has been in the engineering consulting field for over 33 years. He is a member of the American Public Works Association, Urban Land Institute, where he has served as a board member of the Kansas City District Council, and Design Build Institute of America.

Mike has also been deeply involved in the greater Kansas City community for almost thirty years. He has served as chairman of the Blue Springs Economic Development Coucil; chairman of Don Bosco Centers; and president of the Kansas City Industrial Council. Presently, he is a board member of Mutual Aid Exchange Insurance; board member of CU Holding Company; advisory board member of Enterprise Bank and Trust; board member of the Kansas City Area Development Council; board member of KC SmartPort; board member of the Lee's Summit Economic Development Council; and member of the Downtown Kansas City, Missouri Rotary Club. He is a 2007 graduate of the Greater Kansas City Chamber's Centurions Leadership Program.

Mike and his wife Susan have been married for 28 years. They have three young adult children.

Mary Lamie

Mary Lamie was selected to lead the St. Louis region's new freight district in July of 2015. As Executive Director her initial responsibilities will be to evaluate the freight needs of the bistate region and the freight network's current operational status. She will develop public-private partnerships and create the foundation for planning, marketing and advocacy of the bistate region as a national freight hub.

Mary is a professional engineer with over 25 years of experience in transportation, engineering and management, including 22 years with the Illinois Department of Transportation. For the last seven years of her time with IDOT, she has served as Deputy Director of Highways Region 5 Engineer, where she was responsible for 27 counties in southern Illinois, 3,300 lane miles of state highways and 1,700 bridges. Her engineering and project management experience includes a wide variety of transportation projects that require extensive coordination with local, state and national leaders. Her most recent efforts have also focused on working with governmental agencies and the private sector to develop transportation priorities and funding strategies.

Mary received her Bachelor of Science in civil engineering from the University of Missouri-Columbia and her Masters of Science degree in civil engineering from the University of Missouri Science and Technology.

Elizabeth Loboa

Elizabeth G. Loboa received her B.S. in Mechanical Engineering from the University of California, Davis and her M.S.E. and Ph.D. in Biomechanical Engineering and Mechanical Engineering, respectively, from Stanford University. In 2003, she accepted a position as an Assistant Professor and the first external hire in the newly formed Joint Department of Biomedical Engineering at the University of North Carolina at Chapel Hill and North Carolina State University. Dr. Loboa stayed with the Joint Department of Biomedical Engineering at UNC-Chapel Hill and NC State University until October 2015, at which time she was a Full Professor and the Associate Chair. She was also a Full Professor in the Department of Materials Science and Engineering at NC State University and held adjunct faculty positions in the Departments of Fiber and Polymer Science (NCSU), Physiology (NCSU), Biotechnology (NCSU), Curriculum in Oral Biology (UNC-CH), and Orthopaedics (UNC-CH). Beginning October 15, 2015, Dr. Loboa became the 11th dean and first female dean of the College of Engineering at the University of Missouri, Columbia, in its 178 year history. In August 2018, she was also named Vice Chancellor for Strategic Partnerships for the University of Missouri, Columbia. Recently, Dr. Loboa was elected as a Director of the Engineering Deans Council Executive Board for the American Society for Engineering Education.

Tony Luetkemeyer

Tony Luetkemeyer is the State Senator for the 34th Senatorial District, representing Buchanan and Platte Counties. Sen. Luetkemeyer was elected to the Missouri Senate in the November 6, 2018 general election, after winning the August 7, 2018 primary.

After graduating from high school, Sen. Luetkemeyer attended the University of Missouri in Columbia. During his junior year, he was elected Mizzou's student body president. In that role, he advocated for students at MU to

ensure their voices were heard by university administrators. It was also while campaigning for office that Sen. Luetkemeyer met his wife, Lucinda

During the summer after college, Sen. Luetkemeyer worked as a White House intern in the Domestic Policy Council under President George W. Bush. The expertise and commitment to public service displayed by White House staff showed Sen. Luetkemeyer how bright, motivated individuals can shape public policy and make a meaningful difference at the highest levels of government.

At the end of his summer in the Nation's Capital, Sen. Luetkemeyer enrolled at the University of Missouri School of Law. While in law school, Sen. Luetkemeyer was appointed by Missouri Governor Matt Blunt to serve on the University of Missouri Board of Curators, the governing board for the UM System. In that role, Sen. Luetkemeyer fought to keep tuition and fees low for Missouri students and families and served as a voting member on the committee to hire a new university president.

After graduating from law school, Sen. Luetkemeyer clerked for a judge on the Missouri Supreme Court. He understands the importance of limited government and the individual rights and liberties protected by the U.S. Constitution and Bill of Rights. He will be a consistent voice against government overreach in the State Senate. He currently practices law in Kansas City.

Patrick McKenna

Patrick K. McKenna became Director of the Missouri Department of Transportation in December of 2015. As director of MoDOT, Mr. McKenna oversees all operations of the department.

Prior to coming to Missouri, he served as the deputy commissioner of the New Hampshire Department of Transportation. Mr. McKenna spent 13 years in Washington, D.C. working in the United States Senate, where he most recently served as chief financial officer.

Mr. McKenna is vice president of the American Association of State Highway and Transportation Officials (AASHTO) and is a member of its executive committee. He served as president of the Mid America Association of Transportation Officials for 2017-2018. He is a member of the executive committee for the National Academy of Science's Transportation Research Board (TRB), a national group that provides innovative, research-based solutions to improve transportation. TRB is a division of the National Research Council of the United States which serves as an independent adviser to the president of the United States of America, Congress and federal agencies on scientific and technical questions of national importance.

Mr. McKenna has a Bachelor of Science degree in Finance from Bentley College and a Master of Science in Management and Finance from the University of Maryland University College.

He and his wife, Suzanne, are enjoying raising two sons, Patrick Jr. and Connor and a daughter, Kelsey.

Dan Mehan

Dan Mehan is the President and CEO of the Missouri Chamber of Commerce, the state's leading business advocacy organization. A longtime champion of the state's infrastructure, logistics, and workforce assets, Dan is focused on making Missouri the most competitive business climate in the United States. As the leader of

the Missouri Chamber of Commerce, Dan was responsible for producing its 15-year strategic plan, Missouri 2030: An Agenda to Lead.

Joe Reagan

As Managing Member of One Stone Development Co, LLC, Joe Reagan brings over 25 years of executive experience as CEO, COO, functional leader and entrepreneur to each client assignment.

One Stone Development Co supports clients at the intersection of *people* and *strategy* through project leadership to drive change, coaching leaders driving change and strategic guidance on "what's next."

Joe is an inspiring leader recognized for his bold vision, collaborative leadership, and decisive action. His leadership ability has been tested in tough times, both meeting challenges and seizing opportunities for stakeholders. As an outcome, Joe has led people to success in the most complex situations facing businesses and communities in America today. Throughout his career he has worked alongside accomplished CEOs, business owners, Mayors, Governors and other community leaders to achieve results as a dealmaker, innovator and team builder. As CEO of Greater Louisville, Inc., Joe was a Leading organizer and strategist to fund, finance and build the $2B Ohio River Bridges Project through an innovative public-private partnership. He co-founded a broad private-sector coalition that led advocacy to pass legislation in Kentucky and Indiana resulting in the creation of the Ohio River Bridges Authority and served as a founding member of the Authority that crafted the financing and funding plan.

Joe is a passionate advocate for racial equity, educational attainment and stoking the entrepreneurial spirit.

He is affiliated with the Oliver Group and the Leadership Pipeline Institute delivering people and strategy solutions for growing companies throughout the Midwest and Southeast.

Most importantly to Joe, he and his wife, Julie, are parents to seven wonderful children.

Clint Robinson

Clinton Robinson is an Associate Vice President and Director of State & Local Government Affairs at Black & Veatch. He is Professional Engineer registered in Kansas and Missouri and spent the first 25 years of his career designing water and wastewater treatment facilities in North and South America. More recently in his last 10 years he has been responsible for Community Affairs and Government Affairs around the country. In this role he has been successful being an educator, collaborator and story teller with elected officials to explain the most exciting engineering projects around the world.

His passion for the Hyperloop has created national platforms where he has promoted the technology and capabilities of this new form of high speed transportation.

Caleb Rowden

Senator Caleb Rowden was elected to the Missouri Senate in 2016, representing Boone and Cooper Counties. Prior to his election to the Senate, Rowden served two terms in the Missouri House of Representatives. He was first elected to the Missouri House in 2012, becoming the first Representative in the history of Missouri to beat

two former State Senators in a Missouri House race. Rowden was reelected in 2014 by an impressive 63-37 margin.

Senator Rowden is married to Aubrey Rowden, the co-owner of Love Tree Studios, a wedding photography company based in Columbia, MO. They are proud parents to Willem Keane and Adele Lisette. In addition to his legislative duties, Senator Rowden owns Clarius Interactive, a media and marketing company also based in Columbia.

Senator Rowden's passion for serving others is what has motivated and informed his career as an elected official. He is as committed and passionate as he has ever been in his resolve to see this community continue to be a great place to live, work and raise a family. Senator Rowden has been steadfast in his support for K-12 and Higher Education and has played a significant role in creating a positive environment for Missouri's small businesses through his work as Chairman of the Missouri House Economic Development committee.

Andrew Smith

Andrew G. Smith is the co-founder of the Missouri Hyperloop Coalition, a public private partnership comprising the St. Louis Regional Chamber, the Kansas City Tech Council, the University of Missouri System, the Missouri Department of Transportation, the Missouri Innovation Center, Heartland Hyperloop, Inc., and the Missouri Department of Economic Development. The Coalition, with its partners Virgin Hyperloop One and Black & Veatch, produced the first hyperloop engineering feasibility study in North America. Smith began his career on Wall Street as an associate with the hedge fund D.E. Shaw & Co. From there, he joined several digital media startups, where he led fundraising, business development, and strategic marketing functions. Smith ultimately started his own company, Dietsmart.com, which he led to profitability and ultimately sold. He has held leadership positions with Signature Healthcare, LLC as well as Churchill Downs, the home of the

Kentucky Derby. Most recently, Smith served as Vice President of Entrepreneurship and Innovation at the St. Louis Regional Chamber, where he helped launch the Spirit of St. Louis Seed Fund and managed the organization's efforts to promote the St. Louis region's burgeoning startup scene. Smith is a graduate of Dartmouth College and lives in Chesterfield with his wife Cheryl and their two boys, Finn and Rowan.

Greg Steinhoff

Greg and his wife Holly are Columbia natives. They have two daughters, Kristen is an architect in Kansas City and Lauren is an tax accountant with KPMG. Greg graduated from Westminster College in 1981 and received a degree in Pharmacy from UMKC in 1984. After moving back to Columbia, Greg co-founded Option Care, Inc in 1985. The company grew to over 400 employees throughout mid-Missouri. Following twenty years in the homecare business, he decided to accept an appointment from Governor Blunt to serve as director of the Missouri Department of Economic Development. Upon the conclusion of his term, Greg worked as an Executive Vice President at Boone County National Bank and for the last 9 years has been an executive with Veterans United here in Columbia.

Greg has acted as chair of several community boards including the Columbia Chamber of Commerce, Columbia Are United Way, Columbia Independent School, Missouri Technology Corporation and others. He enjoys his Saturday morning golf group in the summer and a duck blind in the winter.

Kaven Swan

Kaven Swan is a principal and director of business development for HOK's global Aviation + Transportation group. He is based in St. Louis.

Kaven has more than three decades of experience with airport terminal programing, planning, design and construction as well as planning heavy rail, light rail and commuter rail and people mover systems related to airport development.

Tariq Taherbhai

Tariq Taherbhai is the Chief Operating Officer for Aon's Global Construction & Infrastructure specialty. In his role, Tariq is charged with ensuring that the full capabilities and expertise of Aon are properly delivered to the firm's global construction and infrastructure clients, and that the operational excellence imperatives of the global specialty are fully realized. Tariq is also the relationship lead for certain Aon clients.

Before joining Aon, Tariq was vice president of the project legal group at Infrastructure Ontario, with responsibility for all legal and procurement matters related to public private partnerships procured by the Province of Ontario. Previously, Tariq worked as an attorney in private practice for approximately five years before joining Infrastructure Ontario.

Leonard Toenjes

Leonard Toenjes is currently the President of AGC of Missouri. Current appointments include serving as a trustee on the AGC of America Education and Research Foundation, Vice Chair of the Missouri Workforce Development Board, a member of the State Board of Mediation, Chairman of St. Louis Metropolitan Sewer District Rate Commission, and a board member of Citizens for Modern Transit and the Mercury Alliance. He is a Certified Association Executive by the American Society of Association Executives.

He has also served on AGC of America's Executive Committee, as Chairman of the Executive Leadership Council of AGC, and the Executive Committee of the American Road and Transportation Builders Association.

Past statewide appointments include chairperson of the Missouri State Council on Vocational Education, a member of Missouri's School to Work Transition Committee, and the Disparity Study Oversight Review Committee. Past local appointments include serving as a school board member for the St. Louis Career Education District, a member of the Mayor's Charter School Advisory Board.

He previously headed the AGC of St. Louis as president, a position held since January, 1996. In 1990, he became the Director of Apprenticeship and Training for AGC of St. Louis and a member of AGC of America's Workforce Development Committee. He graduated from the Construction Training School as a journeylevel carpenter in 1976. He subsequently worked as a union carpenter and taught as an instructor for the St. Louis Carpenters Joint Apprenticeship Program. Leonard served as coordinator of the St. Louis Carpenters Joint Apprenticeship Program for 8 years.

He has authored 6 construction related textbooks currently published by American Technical Publishers.

Bill Turpin

Bill currently has two roles: 1) Interim Associate Vice Chancellor of Economic Development at the University of Missouri and 2) President and CEO of the Missouri Innovation Center. Bill works with faculty and students from the University of Missouri and local entrepreneurs to start and grow technology-based companies. MIC also operates the MU Life Sciences Business Incubator at Monsanto Place with over 60 clients commercializing new technologies in areas such as medical devices, pharmaceuticals, animal health, agriculture, and alternative energy. MIC also operates the Mid-MO Tech Accelerator commercializing new digital technologies, such as virtual reality and online marketplaces.

Over his 30-year career, Bill has financed, acquired, and sold a variety of high-tech companies. He has been the founding CEO of 4 startups and a senior executive at respected public companies including Netscape and Borland. He has successfully secured investments from prominent venture capitals firms, including Kleiner Perkins, and was an Entrepreneur in Residence at Redpoint Ventures. He participated in the groundbreaking Netscape IPO in 1995. And along the way, Bill served as a mentor and angel investor to many Silicon Valley startups. Bill moved back to Missouri in 2014 to help create new companies and grow the Missouri economy.

Bill has a BS in Electrical Engineering from the University of Missouri and an Executive MBA from the University of Texas.

Austin Walker

Austin is the Vice President of Government Affairs at the St. Louis Regional Chamber where he works closely with elected officials at the local, state and national level in Missouri and Illinois on behalf of the region's business community. Before working at the Chamber, Austin served as the Senior Policy Analyst at the National Council on Independent Living (NCIL) in Washington, DC. There he worked with Congress and the White House to create policy and legislation to help and serve Americans with disabilities.

In addition to his professional duties, Austin is a member of the Board of Directors of the Greater East St. Louis Business Development Association, Citizens for Modern Transit, and serves as an Honorary Commander at Scott Air Force Base in Illinois.

Austin received his Bachelor of Arts degree in Political Science from the University of Kansas.

Ryan Weber

Ryan currently serves as President of the KC Tech Council, an industry association and regional advocate for Kansas City's tech industry. He represents KC's tech industry internationally as a board member and vice-chair of the Technology Councils of North America (TECNA). At a state level, he serves as a member of the Missouri Hyperloop Coalition, and locally as an advisory board member for Summit Technology Academy and Blue Valley Center for Advanced Professional Studies (CAPS).

Ryan is a graduate of the Centurions Leadership Program and was recently listed in the Kansas City Business Journal's "Power 100," a list of the most influential business leaders in the KC region.

Brian Williams

Senator Brian Williams, a Democrat, represents the 14th Senatorial District, comprising of Part of St. Louis County. He was elected to the Missouri Senate in 2018. He previously worked as a congressional staffer for U.S. Representative Wm. Lacy Clay. This position enhanced his skills in strategic planning, coalition building and bringing resources to the community. Studying government and public health policy led Sen. Williams to pursue a career in public service.

Senator Williams received an undergraduate degree from Southeast Missouri State University, and his Master's degrees in Public Policy and Legal Studies from Washington University in St. Louis.

Senator Williams is a Board Director for People's Health Center, a quality health care center in Ferguson, Missouri. As a Congressional ACA Coordinator, he facilitated the rollout of the Affordable Care Act (ACA) in Missouri. He also works to connect unemployed and underemployed people with job opportunities at local career fairs.

ADVISORY MEMBERS

In order to avoid potential conflicts of interest relating to a possible tubed transportation project in Missouri, certain members of the Blue Ribbon Panel, primarily those members of the executive branch of government who might eventually serve in a future regulatory role have served on the Blue Ribbon Panel in an advisory capacity only rather than as voting members with final say or sign off on this report, its findings, and conclusions. Those members include:

Patrick McKenna

Tom Blair

Rob Dixon

Rhonda Hamm-Niebruegge

Acknowledgements

Special thanks to Black & Veatch, Olsson, The University of Missouri, MODOT, Washington University, The Missouri Chamber of Commerce and Industry, Economic Leadership Group, Virgin Hyperloop One, and Akin Gump for their assistance in preparing this report.

[i] From 2015 Road to Tomorrow Global Challenge Proposal: "Rural communities will realize economic benefits by retaining residents who can now easily commute to remote urban job centers. No more will people whave to migrate to urban job centers [with higher costs of living]. Barriers to employer access to employees are eliminated while maintaining and strengthening the character vitality, and economy of rural communities. Job growth in one area of the state is no longer detrimental to economic opportunities in other parts; nor is job growth limited to areas of existing employee populations."

[ii] https://www.transportation.gov/policy-initiatives/buildamerica/infra-grants-faqs